RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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## THE SURGICAL TREATMENT OF POST-RADIATION KERATOSIS[1]

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### PATHOLOGY

WOLBACH (1) has reported clearly the pathologic findings of excessive X-ray exposure from clinical and experimental observations. Our own clinical pathologic findings bear out his conclusions, which he has summarized as follows:

"1. Complete loss of appendages of the epidermis.

"2. Replacement of the normal collagen (connective tissue constituent) by a peculiar dense hyaline collagen rich in elastic fibers and poor in cells.

"3. Obliterative processes in blood vessels of the corium and subcutaneous tissues.

"4. Necroses of varying sizes in the corium immediately beneath the epidermis. In the earlier stages these are usually in the region of thrombosed telangiectasis. In the later stages telangiectasis may be nearly entirely absent.

"5. In response to necroses of the corium, reparative proliferation on the part of the epidermis," which may extend beneath the telangiectasis or areas of necrosis. "These small necroses containing the thrombosed telangiectases become completely separated from the skin by the layer of regenerated epithelium and persist for a time as dry dark-colored spots—the 'coal spots'—until cast off. The significance of these processes lies in the fact that invariably present in chronic X-ray dermatosis even after the lapse of many months or several years since the last exposure to radiation."

The epithelium is thought by Wolbach not to be affected by the rays, and to show normal activity for years. But malignant properties may be acquired after years of excessive downward proliferation that is called forth by the changes in the corium and subcutaneous tissues.

### CONSIDERATIONS RELATING TO TREATMENT

The described pathology affords ample reason for getting rid of the affected areas. The stage, size, and location of the lesion will all have a bearing on the type of elimination and repair necessary (2).

Within a few weeks after a heat burn and most mechanical injuries that destroy the life of tissue, the plane of limit between the devitalized and the vital or live tissue has become sharply defined, and it is only when an immediate débridement and repair are attempted that there may be any difficulty in recognizing the demarcation. This is not true with radiation lesions, and in débridement of the latter, months afterward, one may have difficulty in determining whether he is making unnecessary sacrifices or is leaving tissue of doubtful vitality. This

[1]Presented by Dr. Blair before the Radiological Society of North America at the Seventeenth Annual Meeting, at St. Louis, Mo., Nov. 30–Dec. 4, 1931.

may partly explain why attempts to grow skin grafts after excision of certain types of radiation lesions have given a higher percentage of failures than after any other type of injury. The older lesions that have been scarred over for several years are not especially bothersome in this respect; the real difficulties are encountered in attempting to clean up indolent raw or painful areas that persist in spite of all forms of treatment and neither heal nor make a frank slough.

Fig. 1-*A (left).* Condition following exposure under fluoroscope for locating a bullet. This is perhaps the most typical kind of lesion. There is telangiectasis, scaliness, pigmentation, ulceration, atrophy, and extreme pain. Note that the arm shows a milder type of lesion. This gave no trouble and could be left alone as long as there was no progress in it.

Fig. 1-*B (right).* After 10 days of continuous hypertonic packs, the area was completely excised and immediately covered with thick split grafts from the thigh. Here there is shown complete healing after 4 weeks. The upper roughened area is due to delayed healing because of a blood clot. This patient was free of the extreme discomfort of the lesion as soon as he awakened from the anesthetic, and has remained so.

From clinical observation we have concluded that the most potent factor for evil directly responsible for the high percentage of morbidity or mortality of skin grafts in the above type is possibly a sort of fraternization between the *Staphylococcus* and the damaged surface tissues, the latter tolerating an indolent growth of the organism without immunizing the immediately underlying layers. Following removal by knife dissection, even down to apparently normal tissue, immediately applied skin grafts are very apt to be partially or even totally destroyed by pus infection. However, we think we have ample evidence that special pre-operative care of the areas will lessen the risk.

This care includes the application of frequently changed mildly antiseptic or hypertonic salt packs for a few days or until active suppuration is under control. Then, after a débridement, split skin grafts are immediately applied which entirely cover the surface in as large pieces as can be obtained (2). (Figs. 1-*A*, 2-*A*, and 3-*A*.)

REPORTED METHODS OF TREATMENT

Among the many different ideas for conservative treatment recorded, there is a noticeable lack of uniformity of purpose; in practice, some seem to us good, some questionable, and some definitely bad for the patient. As beneficial, we would class all soothing and non-irritating protective measures that give comfort or promote healing, and, as distinctly harmful, the use of mild caustics, irritants, strong antiseptics, ultraviolet radiation, or further exposure to

X-ray burn scars, keratoses, carcinoma. Patient referred by Dr. C. S. Venable.

Fig. 2-*A (left)*. The hand of a physician, an early worker with X-ray. The two fingers had already been amputated because of extreme change and at the base of the thumb definite low grade squamous-cell carcinoma had developed. Amputation above the wrist was advised but, because of the necessity of some part of a hand for his work, another plan of treatment was followed. Half of the hand was amputated, the cover was removed from the dorsum of the two remaining fingers, and an abdominal flap was put in place.

Fig. 2-*B (right)*. The hand 30 months after the rest of the covering has been removed and replaced by a thick split graft. The free graft limits are within the dotted lines.

Fig. 2-*C*. Same case as shown in Figures 2-*A* and 2-*B*. The other hand one week after a number of its keratotic areas had been excised at one operation and replaced with these grafts.

Fig. 2-*D*. The same hand 20 months later showing the smoothing out of the grafts that occurred without further operation. (Unretouched photograph.)

X-ray or radium, though each of these has been repeatedly recommended in the literature. (Figs. 4-*A*, 4-*B*, and 4-*C*.) Skin that has been exposed to major doses of radiation is apt to be abnormally sensitive to chemicals, especially those derived from the heavy metals such as lead, bismuth, mercury, iodine, etc., and for this reason we have felt (along with many others) that applications of a mild sort only should be used on these areas. There have been reported unexplained instances wherein dermatitis or keratosis has developed years after exposure to the rays in which most probably a secondary determining irritation was overlooked, and there are cases in which an already recognizable lesion has been made definitely and permanently worse by irritants such as iodine, bromine, mercury salts, picric acid, and other like chemicals. We would also caution against the use of proprietary preparations of unknown contents; in particular, a certain one of the latter which contains bromine and is locally analgesic has repeatedly been cited to us as the mischief-maker.

### TREATMENT OF INDIVIDUAL LESIONS

The procedures most commonly used for the destruction of an area are electrodesiccation or coagulation, cautery, or sharp dissection. If immediate skin grafting is to be done, the preliminary treatment of the area with mild antiseptic or hypertonic saline moist dressings is a necessary precaution in cases in which ulceration or heavy crusting is present. It may be advantageous to shift adjacent or distant tissue in to cover the defect, most often over joints and for deep burns and those about the face that require good cosmetic result.

*Superficial telangiectatic areas* may be left untreated if there is no tendency to activity and no discomfort. These areas may fade out in time and possibly give a satisfactory


Fig. 3-*A*. Hand of a doctor with an X-ray dermatitis of many years' standing. Fairly rapid activity occurred for one year on fourth finger.


Fig. 3-*B*. Result of removal and skin grafting. Microscopic examination thought to be negative for real carcinomatous change.

bearing surface throughout life. (Figs. 1-*A* and 1-*B*.)

*Telangiectasis* with *scaliness, areas of slight keratosis* and *ulceration* usually mean deeper involvement and there is nearly always some atrophy apparent. These areas are unsightly, are usually uncomfortable, and rarely recover a sufficiently normal condition to warrant one in leaving them. Fairly superficial excision will usually suffice (going deeper in areas of keratosis and ulceration), and the defect is covered immediately with thick split or full thickness grafts (2).

*Ulceration, heavy keratosis,* and *widespread telangiectasis,* usually accompanied by subcutaneous atrophy and marked discomfort of burning and "pulling" sensations, might be said to be the popular idea of a radiation lesion. (Figs. 1-*A* and 1-*B*.) The treatment of these areas calls for widespread excision or destruction followed by suitable repair of the defect.

*"X-ray hands,"* found most frequently in doctors, respond best to wide excision through the full thickness of the skin, and repair with thick split grafts. This procedure gets rid not only of the individual keratosis, but also of the intermediary damaged skin. Small isolated keratosic spots are removed with the actual cautery or electric current, and spontaneous healing is awaited. (Figs. 2-*A*, 2-*B*, 2-*C*, 2-*D*, 3-*A*, 3-*B*, and 3-*C*.)

*Carcinomatous changes* in the irradiated tissues may further complicate the problem. (Figs. 2-*A*, 2-*B*, 2-*C*, 2-*D*, 3-*A*, 3-*B*, and 3-*C*.) The simple superficial epitheliomas will not, as a rule, require excision deeper than the subcutaneous fascia and the resultant defect can be immediately repaired. In dealing with these it is usually our practice to include in the excision the whole area of damaged skin and immediately replace it with a pocket flap or with a free skin graft, rather than, as has been the more common custom, make a number of small local excisions and Thiersch graft. There are roentgenologists who have had a great number of these limited operations on the hands and who still carry much skin that is potentially cancerous, when the whole damaged areas might have been cleared up by a few well planned operations. The neglected epitheliomas will demand the same excisions or amputations, with corresponding gland-


Fig. 3-*C*. Same case as shown in Figures 3-*A* and 3-*B*. Activity recurring through graft 2½ months later. Amputation done at first phalangeal joint. This is the only one in the whole series in which there was a known recurrence of activity under a graft.

In this series of 90 cases split grafts were used 33 times, full thickness grafts 4 times, and flap reconstructions 26 times.

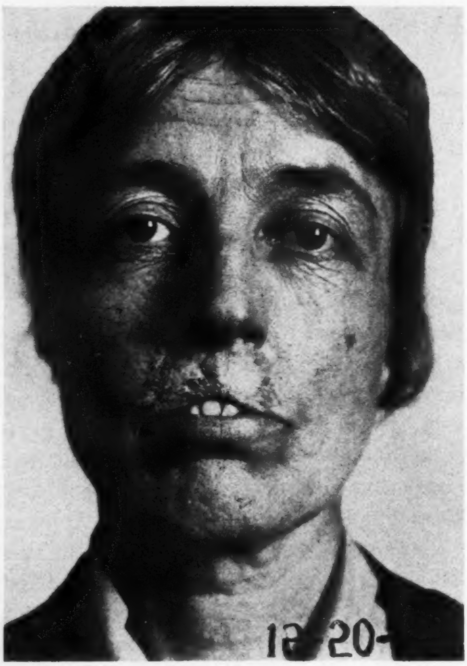

Fig. 4-*A*. Operation had been done on the lip at the age of 5 months. A fairly prominent scar remained, and when the patient was 24 years of age about twenty X-ray treatments were given for it. There was no trouble for eleven years when (the patient being 35 years of age) scaling and soreness began. At this time she was closely associated with an X-ray department. She left this, and had no further trouble for eleven more years (46 years of age), when she was again working in a hospital near the X-ray department.

Since the last trouble (three years previous to present treatment) there has been increasing pigmentation, scaliness, pain, and keratosis. She has had an outdoor, travelling position, with a good deal of sun exposure, and, though she has tried to protect her lip, there has been progress in the disease. Two dental films have been taken during the past year, and she thinks more marked scaliness has resulted.

ular dissections, as will similar cancers arising from any other cause.

Whether it is for the treatment of a radiation lesion, a cancer, or a distorting scar, the consciousness of ability to make an acceptable repair is the greatest stimulant to effective time-saving radical excisions.

*Peri-anal lesions,* the result of treatment for growths or pruritus, offer one of the most difficult types to deal with. Pain and discomfort may be so great as to jeopardize the patient's entire social and physical status. The involved area surrounding the anus is completely excised without damage to the sphincters, and the adjacent tissue of the buttocks is freed far laterally. If this tissue may be shifted over into place and anchored around the anal margin without tension, it is done so, but if there is any wide defect to fill, it will be necessary to free pedicled flaps, leaving defects on the buttocks further lateral. Such flaps will be so thick, and short compared with width, that delay in their transfer to insure blood supply is not necessary, but if an extremely large area is involved, or there is any possibility of opening into the rectum at the time of excision, it is best to have a well planned delayed flap higher up on the back ready to swing down into place.

*Lesions of the sole of the foot* are relatively infrequent but the discomfort to the patient and the tremendous care necessary for their repair make the few cases seem an important part of the lesions in general. The original lesion is usually a plantar wart

Fig. 4-*B*. The whole involved area of the lip was excised. The buccal mucosa was left, as was also some muscle; even this, however, was split clear through in the midline. The defect was covered with a flap that had previously been prepared on the forehead.

Fig. 4-*C*. Final result. Two operations for accurate adjusting of the edges were done, after the flap was returned to the forehead. (Unretouched photograph.)

and X-ray has been the usual form of treatment. Excessive suffering and complete incapacitation may occur during the acute stage, and, if the radiation is followed by a deep hard scar or if the wart remains, the tenderness may persist until the lesion is removed and a good surface established. If a fairly good fat pad is present, and there is no deep hard scar mass after removal of the lesion, repair can be made with a free graft. However, the deep lesions of any considerable size in which there has been a more or less complete loss of the pad may be best treated by the transfer of a flap carrying both skin and subcutaneous fat. The transplanted tissue taken from a non-weight-bearing surface such as the thigh or leg is usually slow at developing sufficient cornification to resist the wear and tear of its new duties without the protection of adhesive plaster, and some protection must be afforded it. When the repair is over a considerable area of the sole, the lack of sensation predisposes to trophic pressure ulcers. If a suitable flap could be obtained from the sole or from the side of the foot where the skin has become accustomed to shoe-pressure, there would probably be a quicker development of satisfactory function, than when tissue entirely foreign to the sole is used.

*Lesions about the face and neck* occur perhaps more frequently than in any other area. The general rules for riddance of the lesion apply here as for any other place, but the repair of the resultant defect requires the further consideration of the protection

of eyes, and the preservation of facial outline and expression. Thick repair tissue is needed in the face region frequently, and the delayed flap is used more often than in any other part. In this area lesions are apt to follow treatment and supposed cure of malignancies, and another hindrance to repair is the occasional finding within the radiation lesion of some persistence of the original growth. (Figs. 4-*A*, 4-*B*, and 4-*C*.)

*Bone and cartilage lesions* occur most often following radium treatments. They may be extremely painful and persist so, even after total excision of all overlying soft parts. If the bone is viable and repair is made over it, tissue of some thickness should be used in an endeavor to curb the discomfort. Bone and cartilage completely killed by radiation give perhaps the slowest separation of any tissue or lesion in the body. In one patient, who had a costal cartilage necrosis following radium application for parasternal glands, healing did not occur for three years. The guarded use of the actual cautery or multiple drilling may speed separation and actual excision of the involved area is occasionally possible.

*Radium Lesions.*—These are less frequent than X-ray lesions. The pathology is probably the same, but the clinical course presents some differences. The lesions are usually less painful and possibly show more tendency to heal. If there has been a heavy dose, there is more tendency to early wide indolent ulceration without the long slow course of atrophy, telangiectasis, keratosis, and ulceration that follows excessive X-ray. This may be due to the fact that the exposures have been excessive but few in number, whereas the X-ray lesion often follows repeated exposures. A very excessive dose of radium may give a real cautery effect, with a slow separation of slough and practically none of the protracted stages of telangiectasis and keratosis.

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*X-ray Films of Insects.*—X-ray films of insects, believed to be the first ever made, have been taken at the Biological Laboratory at Cold Spring Harbor, N. Y., by Dr. Hugo Fricke and Irwin Sizer. They were made with a specially constructed X-ray tube, using small films such as dentists use. They show many scientifically interesting details of the internal structure of insects, and it is believed that this new method can be used to advantage by students of insect life.—*Science Service.*

# THE TREATMENT OF RADIATION INJURIES OF THE SKIN[1]

By ROLLIN H. STEVENS, M.D., Detroit

CHRONIC radiodermatitis and ulceration soon followed the discoveries of X-rays and radium. Protection of the operator, fairly accurate definition of dosage of X-radiation, at least, automatic timers, etc., have failed to reduce very materially the number of these cases. The use of X- and radium radiation has increased enormously and too many physicians without the necessary training and equipment are using these agents for diagnostic and therapeutic purposes. Then, too, X-ray apparatus, widely advertised for removal of superfluous hair, owned and operated by "beauty shops" and not even supervised by medical men, is steadily adding its quota. Occasionally our best operators, through some carelessness of the staff, or unrecognized sensitivity of the patient's skin, have an accident. Chronic radiation dermatites or ulcers still cause much suffering—and the call for help it is usually so difficult to answer.

The pathology, whether acute or chronic, varies according to location of the lesion and technic of application of radiation.

In chronic radiodermatitis, there is marked hyperactivity of the epidermal cells, which means hyperplasia. Hyperplasia is very likely to lead finally to malignancy, in which the hyperplasia becomes invasive and uncontrolled. The theory has been advanced that the constantly increasing, abnormally developed, half-starved cells in hyperplasia tend to search for food and wander, sooner or later, deep in the tissues. This is evidenced by the epidermal pegs in early cancer, seen deep in the cutis, with the invading army spreading out among normal connective tissue cells from the deepest portion of the pegs. It is a frequent observation that malignancy often develops close upon the heels of hyperplasia.

In the cutis, we note a variable modification of the elastin and collagen fibers, both tending to hyalinize and disappear in spots. The oil and sweat glands disappear and endarteritis takes place under heavy or long continued fractional radiation, which may not have produced a severe dermatitis at the time. As a result of the loss of epithelium and of elastic and connective tissue, atrophy of the skin takes place and dilated vessels develop on the surface. In severe cases, necrosis or gangrene of the skin follows within a few days, or perhaps several years, after irradiation, and a more or less intractable ulcer forms.

Freund was early of the opinion that these late appearing reactions were due to bacterial infections present at the time of irradiation. Forssell has stated that, in the few delayed reactions he has seen, he has found a syphilitic basis. The pathology, so far as I have been able to learn from the literature, is about the same as in those reactions which appear in the usual length of time.

The best treatment of these lesions, if they are not too large and not in unfavorable locations, has been considered to be thorough and wide excision followed by skin grafting. However, the skin grafting often fails and then we have a more or less normal granulating ulcer to deal with, and the scar will be more or less deforming and of somewhat serious import.

Various dressings of salves, paraffin mixtures, etc., have been recommended from time to time, only to be found wanting in relieving the pathology. In the early days, radium was recommended and tried for

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

chronic radiodermatitis. Caldwell tried radium on his hands only to have the lesion made worse. Ultra-violet rays were also recommended and used from the early days on. They are still recommended by some.

Reyn[2] and his co-workers in the Finsen Institute, at Copenhagen, tried out both ultra-violet rays and concentrated Finsen light in some 21 cases of roentgen ulcer and radiodermatitis. Their results, such as permanent healing of ulcers, improvement or cure of telangiectasis, improvement of scleroderma-like atrophy of the skin, were generally good. Reyn goes into detail in the description of the management of the cases. He found experimental justification for the treatment in the work of Hans Jansen, who noted that the treatment of the skin by concentrated arc light, such as devised by Finsen and Reyn, produced the formation of very strong connective tissue, richly supplied with new blood vessels. In roentgen lesions of the skin, Reyn points out, the blood vessels are seriously injured and it might be expected that the light, because of its stimulating effect on the various organs of the skin, especially the blood vessels, would exercise a healing action on the roentgen-diseased tissues. Practically, it worked out this way. The sclerotic scar tissue became soft and pliable, ulcers healed, and telangiectatic vessels disappeared.

Reyn says ultra-violet light either did no good or did positive harm. Apparently the superficially active short wave ultra-violet rays do not react deep enough into the skin to affect the connective tissue and blood vessels, spending instead their great irritative effect upon the epidermis, to no good purpose. The Finsen light, which is composed of the whole light spectrum with the longer ultra-violets only, penetrates deeply into the skin when the latter is under sufficient pressure with the quartz chamber water-cooled compress of the Finsen apparatus. The rays of the visible spectrum apparently play an important rôle, along with the longer ultra-violet rays. Even compression and proper cooling of the light, so as not to burn, are essentials in the treatment. The Finsen light unfortunately is not generally available in this country.

Bruner,[3] in an article on the treatment of roentgen ulceration, tried the Finsen light and found its use tedious, but, if it was given carefully, he could confirm Reyn's results. Every other treatment also required much time.

Using desiccation and electrocoagulation, Pfahler treated a very extensive carcinomatous development on a radiodermatitis covering one side of the chest of a patient who had been treated several years earlier for post-operative carcinoma of the breast. The latter had apparently been arrested and the new carcinoma was a squamous-celled affair, apparently originating in the radiodermatitis. Pfahler effected a complete cure for about four years and much improvement in the scar tissue. Morgan stated that W. L. Clark, of Philadelphia, had had a number of similar experiences.

We have treated two cases of roentgen ulcer and a few cases of chronic radiodermatitis with the Finsen-Reyn light. We report the two ulcer cases briefly.

Case 1. Miss C. H., age 42 years, who had been having uterine hemorrhages for 21 months, was quite anemic. X-ray treatment was given by our staff to the ovaries and uterus through three ports—two anterior and one posterior. One week after completion of the treatment a severe roentgen dermatitis developed in half of the right anterior part treated. This was found later to be due to a leak alongside the filter through a crack in the lead glass bowl. The lesion was treated by warm baths, Dodd's solution, etc. It went on to ulceration on a typical chronic radiodermatitis base. Eight months after the appearance of the lesion,

[2]A. Reyn: Radiology, June, 1926, VI, 457-468.

[3]E. Bruner: Strahlentherapie, April, 1930, XXXVI, 373-384.

Finsen light treatment was begun with a Finsen-Reyn carbon arc lamp and continued every two or three weeks for four months. The lesion was treated through five or six compression ports, first around the border then in the central area, each treatment lasting from three to five minutes. Gradually the ulcer healed, keratotic spots cleared up, and telangiectasis was almost completely cured. The patient has remained well now for 18 months.

Case 2. Miss I. S. developed a very large and painful ulcer from a fluoroscopic examination, done by a surgeon in a small town. She was sent to me four months later, in the fall of 1924. At that time, the ulcer, which was located in the lower part of the back over the sacrum and above, measured $10 \times 20$ centimeters. We dressed it with Dodd's solution and various other applications for several weeks. On March 23, 1925, we started air-cooled ultra-violet light, which we gave in small doses twice a week for about three months. The scar was very sclerotic and dense, telangiectatic, and studded with numerous small, deep, indolent, painful ulcers. We could see no benefit from the ultra-violet light. In August, 1930, we began Finsen light treatment with the Finsen-Reyn lamp, making compression for from three to five minutes, and covering the scar area from the borders to the center. It required 20 applications to cover the lesion. The patient lived 150 miles away and was teaching school, so it was difficult to give the treatment frequently. The séances were repeated about every two to six weeks during a period of five months, the last having been given on December 29, 1930. There is considerable improvement, with healing of practically all ulceration and the scar is in better condition. This patient, however, requires much more treatment. There would be serious difficulties in the way of treating such a case with electrocoagulation and desiccation, and we feel the Finsen treatment is the only therapy we have for her at present. Since it is time-consuming, this treatment is not so practical as we desire.

### CONCLUSIONS

1. There are at present three reliable forms of treatment for roentgen ulcer: *(A)* Ordinary surgery with skin grafting; *(B)* desiccation and electrocoagulation, with, or without, grafting later when the slough clears away; *(C)* Finsen light treatment.
2. We have reported two cases of roentgen dermatitis treated by Finsen light in which favorable results were secured.

### DISCUSSION

Dr. George E. Pfahler (Philadelphia): I am sure radiologists will feel deeply indebted to any surgeon who will take an interest in such a group of cases. The late Dr. Charles Porter was a very great friend to a number of our radiologists, and it is well that we know now Dr. Blair is taking a real interest in this group of cases, always difficult to treat, and in which there is no rule, I believe, to be laid down.

I believe it is incorrect for us to call these roentgen burns. They are radiodermatites or degenerations secondary to irradiation. Radiodermatitis can occur, first, in an acute stage, which may be very acute, or the degeneration may occur years after the irradiation treatment.

These degenerative effects may occur from a single application of X-rays or they may occur from a hundred or more, or any number of small fractional doses, any one of which, or all of which, may never have produced even an erythema.

That is the point we must all keep in mind. The degenerative effects are the result of the cumulative dosage, or the result of the total dosage, and not necessarily of any single treatment. Therefore, it behooves us, as radiologists, in the treatment of these cases, first of all to use the prophylaxis necessary, by making a complete record of the total amount of irradiation that is given.

In my experience, many of these damaging effects have occurred in patients who have gone from one doctor to another, perhaps for eczema, perhaps for a port wine stain, or some other condition. The second or third or fourth or fifth radiologist is entirely ignorant, perhaps, of any previous treatment, or ignorant of the amount of treatment that has been given previously. We should take due caution to inquire about any previous treatment so that there shall be no cumulative effect or secondary degeneration. This latter may occur in massive areas, or in small areas.

The radiologists, themselves, have probably been the greatest sufferers. Generally speaking, these lesions are small. They occur as late degenerative effects from many unmeasured doses—small irradiation effects that would not produce an erythema at the time, but result in this cumulative effect. You may have noticed the hand of the radiologist pictured in the series of slides shown by the essayist as Figure 2. All of the effects, I think, were on the left hand, occurring in the case of a radiologist in the early period when it was customary to use the hand as the test object, to see if the tube had the right penetration. As a consequence, the hand received the brunt of the effect. To-day those cases are gradually passing. We do not have to measure our radiation in this manner. Many of my colleagues who sacrificed their hands and their lives as a result of this very practice, received their effects in the way I have described, and not through any single or careless application.

I have had personal experience, and have taken from my own hand at least 200 keratoses. To-day my hands are in a fairly good condition, if one overlooks the splitting of the finger nails and so forth. They have been treated locally by electric desiccation, which is practical in those cases in which there is still some subcutaneous tissue and in which the lesions are small. In such cases I believe electrocoagulation is the simplest, easiest method of removing keratoses.

This is what I mean by laying down no rule. If, however, we have a radiologist's hand, or any other hand, in which the degeneration has extended down to the bone, or extended so deeply that you have no subcutaneous tissue to support even a skin flap, then I think amputation is to be done. If you still can get circulation into the flap, then the skin flap, as has been so well described by Dr. Blair, is surely the best form of treatment. Save the tissue in whatever way you can.

I believe that, in any case in which there is an area more than 2 or 3 cm. in diameter which must be removed, it is probably best to have skin grafts done, as Dr. Blair does. If you can remove the lesion surgically, and then place the skin flap or skin graft on immediately, with a reasonable hope of its growing, you have the shortest way out of the difficulty. But, if you are dealing with tissues in which there is not likely to be a supporting blood supply underneath, you can get that blood supply through first destroying the areas by electrocoagulation, usually requiring about three weeks, until the dead tissue is thrown off. Then the area is covered by healthy granulation tissue. It seems to me electrocoagulation stimulates the formation of granulation tissue better than anything else.

That is, in a general way, the plan of action we have carried out. The main thing we should always keep in mind is to avoid these cumulative effects. They may be avoided by eliminating the accidents or by keeping account of the total dosage that is given and never exceeding what the tissues will ordinarily stand.

There is another point which we must keep in mind. Dr. Stevens refers to the treatment of an ulcer in the abdomen, or rather the sacrum. I want to refer to the abdomen. The sacrum is just about as bad; and lesions are seen there because there is rather poor circulation underneath. There is very little blood supply in the fat of the abdomen. Those who have watched the surgeon work know that, when he cuts through the abdominal tissue and abdominal fat very little bleeding is seen, and the surgeon pays little attention to it. When irradiation is applied that is enough to choke off the little capillaries by endarteritis, and necrosis results from lack of nourishment. That is why the abdomen is the greatest area

of all in which there is danger of necrosis from overdosage. In other parts of the body, in which there is better circulation, one can give a larger dose. My estimate is that one should be very cautious when he exceeds from 250 to 300 per cent total dosage over the abdominal tissue. In connection with tissue on the face, not in single doses but in total doses, one can perhaps go to 400 or 500 total without doing damage, because there is better circulation. But, in the end, it is the total dosage, or cumulative effect, that results in the degenerative condition that must be repaired afterward.

Dr. E. A. Pohle (Madison, Wis.): I might emphasize the fact that skin injuries, particularly late injuries, following irradiation, are of great importance to all radiologists. I have always felt that not enough attention is paid to this problem in radiology, in our meetings as well as in the journals.

It is only logical to assume that, since we are using a dangerous type of radiant energy, we should be familiar with the prevention, with the recognition, and, of course, with the treatment of injuries following its application. My own experience has been limited mostly to the treatment of late injuries; that is, reactions appearing after a period of from six months to many years following the last exposure. I have not seen or treated such extensive cases of injury as Dr. Blair has presented. My own therapy has been done by three means: electrodesiccation or coagulation, ultra-violet light, and the carbon arc.

I agree with Dr. Pfahler that the proper treatment for small keratoses and small beginning ulcers, in which there is enough tissue left beneath, is destruction by coagulation. We have felt that treating these desiccated areas afterward by ultra-violet rays sometimes hastened the formation of the scar. However, you know it is very difficult to express the percentage of additional benefit obtained by this irradiation from the quartz mercury vapor lamp or carbon arc.

From the literature, it appears that treatment by ultra-violet light, or at least that part of the ultra-violet spectrum emitted by the quartz mercury lamp, is not so beneficial as the Finsen arc. I have not been able to use the Finsen arc, because we have not had one at our disposal. The exposure to ultra-violet radiation as emitted by the quartz mercury vapor lamp, adds definitely to the skin reaction produced by X-rays. It was most interesting for me to note that, in several cases of late reactions, we have obtained very definite benefit from exposure to the air-cooled quartz mercury vapor lamp. If I remember correctly, these observations were confirmed in the discussion of a paper of ours by Dr. Chamberlain during the Toronto meeting.[1] In spite of the fact that the effect of short ultra-violet rays enhances the erythema produced by X-rays and radium, the same rays may exert a beneficial effect on injuries produced by radiation of short wave lengths.

Dr. Arthur W. Erskine (Cedar Rapids, Iowa): Those of us who have seen Dr. Blair's work, and especially those of us who have benefited by his skillful and kindly care, have been amazed at the amount of skin that can safely be removed and replaced, and at the usefulness and the normal appearance of the skin of these split grafts. Most of the hands shown here were grafted with split grafts, only part of the skin being used.

Another point is the fact that epitheliomas developing in skin injured by X-rays seldom metastasize. As Mr. Macintosh says, "They are malignant, but they are not malignantly malignant."

Dr. Pfahler (further remarks): Several years ago, Dr. Martin, Dr. Klauder, and I presented a paper on the damaging effects of ultra-violet rays combined with X-rays, and brought out some points which, I think, are convincing as to the danger of using these two agents at once. There seems to be a contradiction of observations, but we must remember that our paper was based upon an immediate application of the roentgen rays and ultra-violet rays. In Dr. Stevens' case, he had a degenerative effect, and he tried to build up new blood vessels, so that the effect is entirely different. I am not condemning it for this pur-

[1]E. A. Pohle and C. S. Wright: Radiology, April, 1930, XIV, 359.

pose of treating degenerative effects, but it is a mistake, as we tried to bring out at that time, to use the two concomitantly or reasonably close together. That paper was issued because Dr. Sampson, particularly, brought forth the idea that the ultra-violet rays would protect against dermatitis from X-rays. They will not do that, and we must be careful to separate the two agents. The other point is this: if a degenerative effect is present, I believe that excising and skin grafting is the best procedure. But it is also best that we wait until the area has limited itself before we start to do the cutting or we will have a failure and another problem with which to deal. Realize the limitation of the extent of the disease before you start to repair it.

Dr. Blair (closing): No matter for what purpose, you can destroy an area all at once or you can destroy it piecemeal, allowing small areas to heal before attacking others. Our plan is to get a strong soldering iron close to red hot and make the destruction, as far as we think it should be done, at one sitting. Usually from three to five weeks later one can cover the whole area with split skin grafts with a fair hope of having complete, or almost complete, epithelization. If the destruction has gone deeper than the skin and immediate subcutaneous tissue, then we are more apt to make the repair by transplanted flaps. We are not likely to see small lesions. Those we see are more apt to be of a type that Dr. Erskine sent us recently in which half of one side of a man's face was hard scar or keratosic skin, evidencing also some active cancer. This is the type we go after with a soldering iron.

If there is no evidence of active cancer, we are more likely to remove the keratoses with a knife and immediately skin graft the area, with the understanding that possibly not more than half of the graft will take on the first sitting, and that it will have to be regrafted later. If there is a history showing that the original treatment was for active cancer, then, if possible, we destroy with heat as explained above. We have thought that, at times, quiescent buried cancer cells are allowed to become active when such a scar is incompletely removed by knife dissection.

Dr. Stevens (closing): I want to beg of my colleagues never to treat a port wine stain, especially in an adult, with radium. You cannot succeed. In a young baby you can treat successfully small port wine stains, if they are not much larger than 1 or 2 cm. in diameter, but you cannot do it in an adult, or in large port wine stains in a baby.

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*Daughter of Radium Discoverers Confirms Existence of Neutrons.*—New and direct proof of the existence of the new particle of matter called the "neutron" has been obtained by Mme. Irene Curie, daughter of the discoverers of radium, and her husband, Dr. F. Joliot, of the Institut de Radium, Paris, as announced in a communication to the British scientific journal, *Nature*.

Proof of the existence of penetrating radiations which are neither X-rays, such as are emitted from high voltage tubes, gamma rays such as produced from radium, nor electrons was obtained during a bombardment experiment. The two scientists concluded that the rays must be identified with the neutrons, previous evidence for the existence of which was obtained by Dr. J. Chadwick, of Cambridge, England.

The light metal, lithium, was bombarded with alpha particles or charged helium atoms obtained from the radio-active metal polonium. The secondary rays given off from the lithium differed from gamma rays, which had the same penetration through lead because they were much more readily absorbed by paraffin. The penetrating neutron rays obtained by the bombardment of metals like boron and beryllium have the same properties, but there are no known X-rays or gamma rays of the same strength with which to compare them. Dr. Chadwick's assumption of the existence of the neutron depended upon the idea that when neutron rays hit the metal atoms and disrupt them, throwing out bits of inner stuff in the form of alpha particles and protons, these violent collisions follow the same laws of conservation of energy and momentum as the shocks between billiard balls. —*Science Service.*

# PRECANCEROUS AND PSEUDO-CANCEROUS LESIONS OF THE CERVIX UTERI AND THEIR TREATMENT[1]

By GEORGE GELLHORN, M.D., F.A.C.S.
From the Barnard Free Skin and Cancer Hospital, St. Louis

THE great majority of cases of cancer of the cervix, when first seen by the gynecologist or radiologist, are in a more or less advanced stage. The prospect of cure, even at best, is very unsatisfactory so long as our therapy, whether it be surgery or radiation or one of the many combinations of the two, is crude and merely empiric. Until a cause is found at which treatment may be directed, an improvement of the situation can only be hoped for, first, through a widespread education of the laity and profession in earlier recognition of the disease; second, from the study of so-called precancerous lesions and, through the elimination of these, the possibility of *prevention* of cancer.

The term "precancerous" evades an exact definition. By microscopic examination of a given tissue we can only say that it is or is not malignant; we cannot say that it is *not yet* malignant. "Precancerous" has merely a clinical meaning and designates conditions which experience has taught us are fairly often followed by the development of cancer.

First and foremost in this list are *cervical lacerations*. It is a well known fact that cancer of the cervix is much more frequent in women who have borne children than in nulliparous or virginal patients. In the latter the smooth, rounded, or conical vaginal portion contrasts strongly with the wide slit of the external os following this common birth injury. Here the lips of the cervix are everted, and the delicate mucosa of the cervical canal is exposed to manifold bacterial, mechanical, and thermic stimuli. Chronic irritation, to which we ascribe much importance in the causation of cancer, may prove particularly provocative at the border at which the squamous epithelium of the vaginal portion and the cylindrical epithelium of the cervical canal meet. There must, however, be other, still unknown factors at work. Vineberg, for example, found in several thousand parous Jewish patients, observed at the Mount Sinai Hospital in New York, a very much smaller percentage of cancer of the cervix than the usual proportion in women of other racial strains.

Be that as it may, it is necessary—and doubly desirable from our particular point of view—to treat such eversions. I used to be much in favor of electrocauterization but I have lately reverted to surgical measures. At any rate, radiotherapy is not indicated.

An *erosion* represents a highly reddened and often bleeding area on one or both lips of an otherwise normal cervix. It may well become the starting point of a cancer; particularly if the erosion is hypertrophic or follicular, that possibility seems very real. An erosion, which is most often caused by pathologic changes higher up in the uterus, disappears spontaneously after the latter have been cured. Neither surgical nor radiologic treatment is required.

Very suspicious of cancer or a precancerous lesion is a *decubitus ulcer* on the cervix of a prolapsed uterus. The actual development of cancer is, however, of the greatest rarity; and the ulceration heals quickly if the uterus is pushed inward and kept in its place so that the mucosa is protected from further drying out and mechanical irritation.

*Syphilitic lesions* of the cervix unquestionably bear a sinister relationship to can-

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

cer. "Syphilitics," says Horand, "live forever under the sword of Damocles. If cancer occurs in such individuals, it seeks the place previously weakened by a luetic lesion." It is, therefore, very important to recognize such local manifestations promptly and to administer the appropriate treatment.

The diagnosis of a chancre on the cervix is not unduly difficult. But we are, so to speak, attuned to cancer, and think so little of syphilis that the initial sclerosis either escapes our attention or is not recognized as such. Only thus can we explain the difference between the opinions of some of the foremost gynecologists of our time, who claim never to have seen a chancre of the cervix, and the recent, splendid treatise on "Primary Syphilis in the Female," by T. A. Davies, of London, who, in more than five hundred patients, found the primary lesion on the cervix in almost one-half of the cases.

When *secondary syphilitic lesions* occur on the cervix in the form of macules or papules and are associated with like manifestations on the outer skin, the correct diagnosis suggests itself. Much more difficult is the decision if freely bleeding ulcers cover the cervix and vagina. Fortunately, the lesion is quite unusual. On the other hand, the typical secondary ulceration, with its raised and broken surface and pseudomembranous covering, might well impress the unwary as being precancerous, if not already malignant, and mislead him into hasty and ill-advised intervention.

*Tertiary syphilis of the cervix,* either in the form of gummous ulcers or hypertrophic gummas, is likewise strongly suggestive of existing or threatening malignancy. In fact, there would seem to be no difference between such a gumma and a real cancer of the cauliflower type, were it not for the microscopic examination. In gumma the typical connective tissue changes are seen with new formation of capillaries, perivascular infiltrations, and swelling of the endothelium; in the cancerous growth, the proliferation of the epithelium and its invasion into deeper layers dominate the picture.

In dermatology and surgery it has long been definitely established that cancers will often develop on a syphilitic basis. In gynecology, this fact is only now being slowly appreciated. At the Barnard Free Skin and Cancer Hospital, we have paid much attention to the large percentage of syphilitics among our gynecologic cancer patients. Cancer may develop upon the cervix directly out of a syphilitic lesion. I have actually observed this occurrence in two cases and confirmed it by a series of microscopic examinations. Or else there may be an intermediary between syphilis and cancer in the form of a *leukoplakia.* This means a whitish, bluish, or pearl-grayish area which does not rise above the level of the surrounding mucosa. A leukoplakia may be the result of any irritation of long standing, but most often it is caused by syphilis. It has abundantly been proven that leukoplakias of whatever origin show a very strong leaning toward malignant changes. A glance through the microscope makes such observations quite plausible. The normal squamous cell covering of the cervix shows a different behavior if the section is made through an adjoining patch of leukoplakia. There is a proliferation of the epithelium and a tendency toward deeper invasion. From this to the limitless multiplication of the epithelium, the breaking through of the basal membrane, and the inundation of adjoining tissues there is but one step—a step which we, unfortunately, know from clinical experience is taken only too often.

The proper therapy of all these syphilitic lesions is obvious. It is neither surgery nor radiology, but only specific treatment energetically and systematically administered for a period of years. Through it, the dan-

ger of cancer from this particular cause may be prevented. There is a very significant statement by Bergh, of Norway, to the effect that, during the 38 years in which he was in charge of a hospital for prostitutes, he encountered only one case of cancer among them. While it must not be forgotten that, as a rule, prostitutes die young (before they enter the cancer age), yet Bergh's observation seems to indicate that thorough and repeated specific treatment—such as these prostitutes received, nearly all having contracted syphilis early in their careers—has a prophylactic action against the development of cancer.

Finally, a word should be said about *tuberculosis of the cervix.* In the internal genitals, tuberculosis establishes itself most often in the tubes; the cervix is but rarely affected. In the two cases which I have seen in the last six years, a papillary tumor, resembling cancer, occupied the cervix; in fact, in one case the diagnosis was erroneously cancer. It has been shown that tubal tuberculosis predisposes to cancer of the tubes, and the same relationship may, by analogy, be assumed for the cervix.

## CONCLUSION

Lesions of the cervix have been listed which either simulate cancer or may be forerunners of it. Appropriate treatment of the various conditions will cleanse the soil on which cancer may conceivably develop, and contribute toward prevention in a good many instances. Who, then, should be the judge of the suitable treatment? In none of the categories here mentioned is radiotherapy indicated. The fact that a case belonging to any of these groups is referred to you for radiologic treatment would indicate that the physician in charge is not conversant with the nature and diagnosis of the condition in question. In such a case it does not seem fair that you, as radiologists, should bear the burden of making the diagnosis in a field foreign to your work. In the interest of the patient, it would be far better if a competent gynecologist were to act as intermediary between practitioner and radiologist. I know more than one enlightened radiologist who avails himself of the services of a gynecologist as a consultant in doubtful cases. And what is true of precancerous conditions applies equally to cancer of the cervix. Here, too, the familiarity of the gynecologist with his special field would be of inestimable aid to the radiologist to whom cancer of the cervix is but one of the many problems with which he has to deal. It is, therefore, no exaggeration to claim that the best results of radiotherapy of cancer of the cervix are likely to accrue from an intimate co-operation of radiologist and gynecologist.

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*Nicotine Made Less Poisonous by Ultra-violet Irradiation.*—Nicotine is made less poisonous by exposure to ultra-violet radiation. But the raying must be done just right. An overdose of ultra-violet will make it poisonous again. This is, in condensed summary, the outcome of an investigation reported by Prof. Glen Wakeham, Genevieve Wilbur, and Clarence B. Johnston, of the University of Colorado.

Pure nicotine is put into quartz tubes, and exposed to the action of ultra-violet radiation from an electric arc. Then its poisonous effect is tested on rats. The investigators found that nicotine radiated for from one to four minutes, at a distance of 12 centimeters (4¾ inches) from the arc, lost 50 per cent of its toxicity. But nicotine left too long under the ultra-violet became fully poisonous again.—*Science Service.*

# SOME CONSIDERATIONS UPON THE ELECTIVE ACTION OF THE RAYS[1]

By MME. N. DOBROVOLSKAÏA-ZAVADSKAÏA, M.D., Paris

PRACTICALLY, we distinguish two kinds of radiation: (1) heterogeneous, unfiltered radium radiation composed of corpuscular beta rays and all kinds of vibratory gamma rays and the vibratory rays of all possible wave lengths by the X-rays, and (2) more or less homogeneous filtered radiation composed only of vibratory gamma rays and X-rays of the shortest wave length.

Is there anything in experimental radiobiology which would correspond to this division?

The most conclusive response on this question is given by the experiments with radium rays on striated muscles, tissue which is generally considered as not very sensitive to the rays.

If a platinum needle containing a moderate dose of radium salt is placed in the muscles of a rabbit for a fairly long time, two distinctive concentric zones appear around the needle. Gorowitz, Bagg, Lacassagne and others have shown that the *first* of these zones, disposed nearer to the radio-active focus, is a *necrotic* area. It is characterized by the coagulation of the cytoplasm and by the destruction of the nuclei. The connective tissue, as well as the muscular, is killed. The *second* area, sharply defined from the first, is especially characterized by a progressive disappearance of muscular cytoplasm. The latter fact justifies the name of *atrophic* zone; the outside boundary of this zone can be seen quite distinctly.

The destruction of cytoplasm, characteristic of the atrophic zone, is brought about by a process of autolysis; sometimes the muscular fibers simply become thinner, sometimes vacuoles are seen in them. On the other hand, the nuclei prove to be much more resistant, even accumulating in groups or chains. Probably it depends on the fact that the nuclei of the striated muscles multiply by a simple amitotic division and not by mitosis, which is known to be sensitive to the rays.

In spite of the atrophy of the muscular fibers, the connective tissue becomes greatly hypertrophied, gradually replacing the disappearing striated muscles.

I have obtained a conspicuous development of these two zones, using as little as 1.99 mgm. of radium element, and 0.5 mm. of platinum as filtration, but only after a rather long irradiation, namely, 28 days. After 13 days, no delimited zone of necrosis was formed, only isolated fibers in the vicinity of the needle presented some foci of coagulation of their protoplasm. We thus infer that the formation of the zone of necrosis, when filtered radiation is used, is due to the accumulation of the relatively feeble necrotic effects of the secondary radiation from the platinum through a long period of time. Meanwhile, less evident atrophic phenomena have time to attain their full development.

On the other hand, this consideration may also explain why the authors who used very heavy doses of rays, poorly filtered or even unfiltered, for a short time, obtained very easily a necrotic area in the muscles, but failed sometimes to see any modification which could be revealed by the microscope outside of the zone of necrosis.

In the light of all that has just been said, we can answer the question put at the beginning of this paper, that experimental bi-

[1]Read before the Radiological Society of North America at the Sixteenth Annual Meeting, at Los Angeles, Dec. 1–5, 1930.

ology establishes two kinds of effects, two modes of action distinctly, topographically delimited in two zones: (1) the zone of necrosis, corresponding to the heterogeneous radiation and (2) the zone of atrophy, corresponding to the purified homogeneous vibratory radiation only.

There can be no question of any elective action of the rays in the zone of necrosis, or, in other words, when a heterogeneous caustic radiation is used. All cells, all kinds of tissues are killed, burned there without any distinction. The elective action begins only with the atrophic zone, that is, when a filtered radiation is employed. In the atrophic zone, obtained in irradiated muscles, we have already seen the different effects of the rays on the muscular fibers and the connective tissue. The first is destroyed, the second is not prevented from a considerable development.

The conservation of the vitality of the connective tissue is a very important factor in the treatment of malignancy because it is by this tissue that healing of the local process occurs after the irradiation is finished. That is one of the reasons why therapeusis might be directed by something analogous to the phenomena of the atrophic zone rather than those of the necrotic zone. In other words, it is better to produce an atrophy than a necrosis of the cancer cells.

Let me give you another example of still more evident elective action of the rays. The organ which is best adapted for such investigation is the testicle, the spermatogenic elements of which, in response to the rays, duplicate the behavior of the malignant tissues.

The influence of the rays on spermatogenesis has been much studied. It will be enough to mention the works of Frieben (1903), Bergonié and Tribondeau (1904), Thaler (1905), Regaud and Blanc (1905), Mohr (1919), Schinz and Slotopolsky (1925). During the first stage of my investigations on hereditary transmission of radio-lesions of the germ plasm, I made use of the testicle to get more evidence of the modification produced by different doses of X-rays administered under different conditions.

In the seminiferous tubules of a testicle there are two kinds of elements: (1) sustentacular cells, or columns of Sertoli, and (2) spermatogenic elements. The former are generally described as high cylindrical structures which are joined to each other near the basement membrane. Prof. Regaud believes that their protoplasms are fused and form a kind of syncytium surrounding the spermatogenic epithelium. Only the nuclei of Sertoli are well differentiated and they lie in contact with the basement membrane. Their purpose is to furnish nourishment for developing germ cells. The spermatogenic elements are represented by several generations of the cells—spermatogonia, spermatocytes of the first order, those of the second order, spermatids, and, finally, spermatozoa.

Three periods may be roughly distinguished in the development of the male sexual cells from the spermatogonia. The first period, period of proliferation, embraces a repeated mitotic division of the spermatogonia ending in formation of small spermatocytes of the first order. In the second, the period of growth, the small spermatocytes increase greatly in size and change into large spermatocytes of the first order—"mother cells" of O. Hertwig. The third, the period of maturation, is characterized by a modified double mitotic division, without intervening period of rest, and results in the matured spermatozoa. During the third period, a very important and significant process takes place, the reduction in the number of chromosomes, so that in the spermatids the chromosomes are reduced to half the number present in a somatic cell of the same animal. The spermatozoa are

formed from the spermatids by a rearrangement of the constituent elements of these cells. These three periods correspond accordingly to three groups of cells: (1) spermatogonia; (2) growing small spermatocytes of the first order, and (3) all other cells from large spermatocytes to spermatozoa.

What happens in all these cells after irradiation of a testicle? The immediate result is seen only in the cells of the first group, the spermatogonia, and those of the second group, the spermatocytes of the first order, while they remain small. Their nuclei become clumpy, pyknotic, the cytoplasm more acidophil, and the cells die.

The other generations of spermatogenic cells present no visible alteration and continue their habitual course. The degree of alteration can be appreciated only in view of the modifications presented by the succeeding generations. But in this respect, there is also a difference. The spermatozoa, which are seen about two weeks after irradiation and which were developed from the irradiated spermatids, present no visible modification of form. They are in normal quantity and are regularly disposed in the center of the tubule. But the spermatids which appear after the irradiation, and the spermatozoa which develop from these spermatids, are quite ostensibly modified. The spermatids manifest a large variation in size; the spermatozoa, all kinds of monstrosities. These cells evidently originated from irradiated large spermatocytes of the first order. These last cells were, consequently, also altered by the rays, though in another manner than the spermatogonia and the small spermatocytes, and they were able to transmit their own invisible alteration to the following cell generation.

The facts just presented show how various is the behavior of different irradiated elements in the same spermatogenic line of a seminiferous tubule. The difference becomes still more striking when the other elements of a testis are taken into consideration.

If the dose is sufficiently large, the spermatogenesis may be completely cut off, and all spermatogenic elements disappear one month after irradiation. The retracted tubules then contain only perfectly preserved Sertoli nuclei which seem accumulated in the emptied syncytium. I have never seen a mitosis in these cells, but the figures suggesting the idea of a direct division were described and could be found in my preparations too.

Accumulation of interstitial tissue was often noted in a radiologically sterilized testicle, but the question remained if this accumulation was not only a relative one, resulting from the retraction of the emptied tubules. In some of my preparations, I have seen some beautiful mitoses of these cells, so a real increase of the interstitial tissue in a radiologically sterilized testicle may now be held as established.

As the columnar epithelium of vasa efferentia also remains unchanged, it may be concluded that the rays choose for their destructive action only one kind of cells—spermatogenic cells—and leave undamaged all the others. That is what we call the elective action of the rays.

There exists also a perfect analogy in the action of the rays on oogenesis, as studied by Gricouroff on young rabbits from one and one-half to three days old. At that period the ovary of the rabbit, which presents the apogee of the multiplication of the oogonies, contains a great many oocytes at different stages of nuclear differentiation.

The first effects detectable one hour after irradiation are the cessation of karyokinetic multiplication of the connective tissue and epithelial cells, and the destruction of the mitoses which are in evolution. In particular, the multiplication of the oogonies is completely stopped. At the end of 24 hours, they are almost completely destroyed. The oocytes are more resistant and the manifes-

tation of lesions in them is more delayed. The oocytes which persist for the longest time are those which, at the moment of irradiation, are more advanced in their development. As long as the irradiated oocyte is not destroyed, it carries on its evolution, increases in size, and its nucleus prepares for chromatic reduction, having the same rhythm and passing through the same morphologic stages as the normal oocyte.

There is no new formation of oocytes from the undifferentiated cortical elements which have escaped the action of the rays. Oogenesis is definitely checked. The follicular cells, which are not distinguishable from the oogonies by their structure, have a relatively feeble sensitivity; a certain number of them always persist among the last epithelial elements of the cortical zone.

Thus there exists a manifest radiophysiologic parallelism between the homologous stages of the male and female sexual chains. The germinal cells (spermatogonia and oogonia) have an extreme and very specialized sensitivity. The spermatocytes and oocytes of the first order, less sensitive as a whole, become more and more resistant in proportion as they become more differentiated. The rhythm of evolution is not altered by the irradiation in either of the two chains.

The phenomena just described in the testis and the ovary have their full analogy in what is going on in a correctly irradiated squamous-cell epidermoid. Only the cancerous cells, and especially those which give rise to the new generations of cancerous cells by their continuous reproduction, are attacked by the rays. The cells of surrounding normal tissues—skin, muscles, and, more particularly, those of connective tissue—keep their vitality and contribute to definite healing of malignancy.

In cancer, the elective action of the rays may display itself because of a particular readiness of the cells of an epithelioma to respond to the rays. But not all cancerous cells are so responsive. Adenocarcinomas generally do not manifest this capacity and their radiotherapy is, therefore, much more hopeless. This may be very well demonstrated by a comparison of a squamous-celled epithelioma of the cervix uteri, which may be radically healed by the rays, and a glandular columnar-celled epithelioma of the body of the uterus which is better untouched by the rays, but is to be operated on as soon as a diagnosis is made.

As the glandular carcinoma may be also temporarily diminished by irradiation, different behavior of these two kinds of malignancy is generally designated as a more or less pronounced radiosensitivity, corresponding to more or less large doses. From this point of view, successful treatment of a glandular carcinoma is impossible because the dose necessary to arrest the disease permanently is incompatible with the preservation of the integrity of the surrounding normal tissues. Such a view reduces the whole difference between all kinds of cells in their relation to the rays to the quantity of these rays. The following facts show that this difference is not only quantitative but also qualitative and that the whole problem is much more complex.

In general biology, the rays are now often used for the purpose of producing such modification in the hereditary material as is manifested by the appearance of modified offspring or mutation. Many of these experiments were made on *Drosophila*. The first investigator, Mavor (1921), obtained a non-disjunction of the x-chromosomes, but no conclusive evidence of gene-mutation, though somewhat over one hundred thousand flies, developed from the irradiated eggs, were studied. The later experimenters, Muller (1927), Hanson (1928), Weinstein (1928), and others, obtained many different mutations in similarly irradiated lots of flies. Little and Bagg (1924) have obtained

abnormal eyes and club feet in mice. I have obtained two mutations—waltzing mice and mice with abnormal tails—in the progeny of irradiated mice. On the other hand, Snyders (1925) produced no mutation in the offspring of irradiated rats. Many positive results were obtained in plants. This allowed some investigators to assert that the rays produce all kinds of mutations. (How clever these rays are, are they not?) Moreover, a hypothesis was advanced that all spontaneous mutations and even the whole problem of the origin of species might be reduced to the action of the rays (cosmic included).

This brings us to the discussion of two points concerned in every radiobiological phenomenon: (1) the physical agent—penetrating rays—and (2) the living cells with their histologic structure, chemicophysical constitution, and the particular specificity which prevents, for instance, the successful transplantation of the parts from one organism to the other even on *Protozoa,* as was recently shown by Dr. Okada (1930). Of these two factors, the penetrating rays do not vary materially. Given exactly the same conditions, this agent may be considered as constant, whereas the living cells present an unlimited variation not only from the morphologic standpoint, but also in their physiologic behavior. So, for instance, the skin of different animals has, on the whole, the same histologic structure, yet, nevertheless, the skin of a mouse is much more resistant to the rays than the skin of a rabbit or a rat.

In a series of unpublished experiments upon irradiation of muscles at a distance, by means of an external radium pack, I have seen isolated striated fibers become coagulated, whereas other fibers nearby remained apparently unchanged. Why was one modified and the other not, when both were irradiated exactly in the same way? The answer may be looked for only in the individual particular state of those fibers, perhaps in their special functional physiochemical condition which changes during the metabolism.

In the light of all observed facts, the elective action cannot be reduced to a certain function of the rays only. Neither may it be understood solely as a more readily quantitative reaction—a response to a smaller dose. Rather it must be conceived as a special qualitative reaction of different living cells to the rays, as an elective individual response in conformity with the nature of the cells, *i.e.,* their fine microscopic structure, their functional peculiarities, their physiologic state at a given moment. So the radiobiologic effect is an interaction of the two factors concerned: rays and living cells, and the electivity of the effect is primarily determined by the individuality of the cell.

If the dependence of the biologic effect of the rays on the object irradiated is a general law of radiobiology, as it seems to be, the law is also to be taken into account in the evaluation of experimental results in the field of genetics. The meager quantities of mutations obtained, in comparison with the huge numbers of unchanged individuals, inconstancy of the results with different strains in animals and plants, and the similarity of the majority of the mutations obtained with those occurring spontaneously, lead us to the conclusion that the rays by themselves are unable to produce any new form. These new forms are produced by the living organisms themselves in cases in which they are capable of producing them. Perhaps the rôle of the rays is only to reveal a pre-existing predisposition, and to give a stimulus to its full development.

The increased mutation rates, obtained lately in *Drosophila* (Muller, Hanson, and others), are probably an expression of the same elective action of the rays which proves to be in the normal and pathologic tissues—an elective individual reaction of

the cells themselves. Only in this case not the cells of an organism, but the isolated organisms of a strain are concerned. At any rate, the result is the same. The response is obtained only from those individuals which, by their nature ("state of premutation" of Cuenot), are predisposed to respond.

The real action of the rays alone is manifested by the zone of necrosis. There is no variation in reaction, no individual response from the cells and tissues. The result is here always the same—death, because it is an effect of a blind physical agent alone—the rays—and this physical agent acts as any other physical agent, as a knife, as a flame, or as a falling heavy object: applied with sufficient force, it kills.

The elective effect of the rays seen in the zone of atrophy is the basis of the whole radiotherapy of cancer, and the progress of radiotherapy depends mostly on the improvement of our knowledge of the conditions which determine the readiness of the cells to respond to the rays.

The individuality of the living cells, whether normal or malignant, is the only key of the whole problem and this points the way to further investigations.

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*Stomach Ulcers Produced by Protein Starvation.*—Ulcers of the stomach are caused by a lack of protein in the diet, as indicated by experiments on rats performed by Frederick Hoelzel and Esther da Costa at the University of Chicago. They kept large numbers of rats on alternate "foodless days" and days when they were given food. They gave different groups of the animals a wide variety of diets, with a range from no protein at all to a comparatively high protein ration. In addition, they kept one good-sized group of rats on a normally balanced ration, as controls. None of the latter developed stomach ulcers, but all of the rats without protein did, and many of those on the lower protein diets as well. In general, there was a distinct correlation between protein starvation and incidence of ulcers.

Some of the rat groups received various other articles along with their measured protein rations. These included spices, antacid salts, alcohol, salt and hydrochloric acid. None of these made any difference, so long as the rats got enough protein.

Neither did bulk of food make any difference. Some of the rats were given almost nothing to eat but bran. They practically starved to death; but because bran contains sufficient protein, when taken in large quantities, they did not develop stomach ulcers. Furthermore, when rats with ulcerated stomachs were put on a nearly exclusive bran diet they got well, in spite of the supposedly irritating effect of the scratchy bran flakes.

As a result of these and other experiments, Mr. Hoelzel recommends a high-protein diet for human sufferers from stomach ulcers. However, he cautions, it will not do to increase the protein intake too suddenly, because other experiments have indicated that ill effects can follow immoderate indulgence in proteins in the early stages of ulcer healing.—*Science Service.*

# THE DIAGNOSIS OF DUODENAL ULCER[1]

By GUSTAV PETER, M.D., Mexico City, Mexico
Translation by W. Winocour, M.D., Mexico City, Mexico

IN a paper read before the seventh Latin-American Congress, Dr. G. Malda expressed rather strong views regarding the method of radiographic gastroduodenal series, even doubting the value of one of the classical X-ray findings in duodenal diagnosis, namely, the "profile" and "front niche" of Åkerlund. These were described by that author in his fundamental study dealing with the method of diagnosis of duodenal ulcer. Having been misled in 52 cases, all of them diagnosed by the radiologist as ulcers, in which the operative findings failed to corroborate the roentgenographic data, or at best elicited only periduodenitis, Malda quotes the two famous Paris roentgenologists, Lapoint and Béclère, who also could not claim to be infallible. Malda cites cases of hematemesis with occult blood, in which the most careful palpation during the operation could not reveal the least sign of any lesion.

As a result of his personal experiences, Malda arrives at the conclusion that all X-ray diagnosis depends to a large extent upon the individual manner of interpreting the findings, which, therefore, according to him, must be subject to grave error. As he puts it: "The radiographic Proteus of the duodenum, taken in X-ray series, changes its aspect from one plate to another, and the radiologist has no absolutely reliable means to prove the correctness of his interpretations, which thus, *nolens volens,* remains of a purely subjective character."

Malda's critical observations go to illustrate the shortcomings of Åkerlund's method of taking from 10 to 20 radiographs in series, leading far too frequently to the diagnosis of a niche. Noelke, in an original paper published in 1929, reported 1,000 cases examined radiologically, among which were 153 with definite roentgenographic findings of duodenal ulcer, not one of which had presented a niche.

The investigations of Albrecht and of Fanardshew, carried out on a large number of cases, go to prove, however, that between the two above-mentioned extreme views we have a safe method for interpretation of roentgenographic findings in the duodenum—the procedures of H. H. Berg. As we shall see later, Berg determines the presence of a duodenal niche by the so-called tangential fluoroscopy, taken in all diameters, laying especial stress on the right and left anterior oblique diameters. Berg takes his plates after exposing his patients to a dosified compression and expression. The niches, or other constant alterations which may thus be revealed, are no longer a matter of subjective interpretations, but have to comply with a typical and objective symptomatology.

This symptomatology, which we shall discuss immediately, was worked out by Åkerlund and Berg and is now the standard method accepted by the German school. Both Berg and Albrecht demonstrated the correctness of their views in a large number of operations.

In his now classic paper, Berg quotes 203 cases operated on for duodenal ulcer. Of these patients, all of whom showed a niche radiologically, only in two was the diagnosis incorrect. Among the others (201 cases), 175 were diagnosed roentgenologically as sure cases of duodenal ulcer, and 36 as doubtful cases. All the doubtful cases proved, on operation, to be duodenal ulcer.

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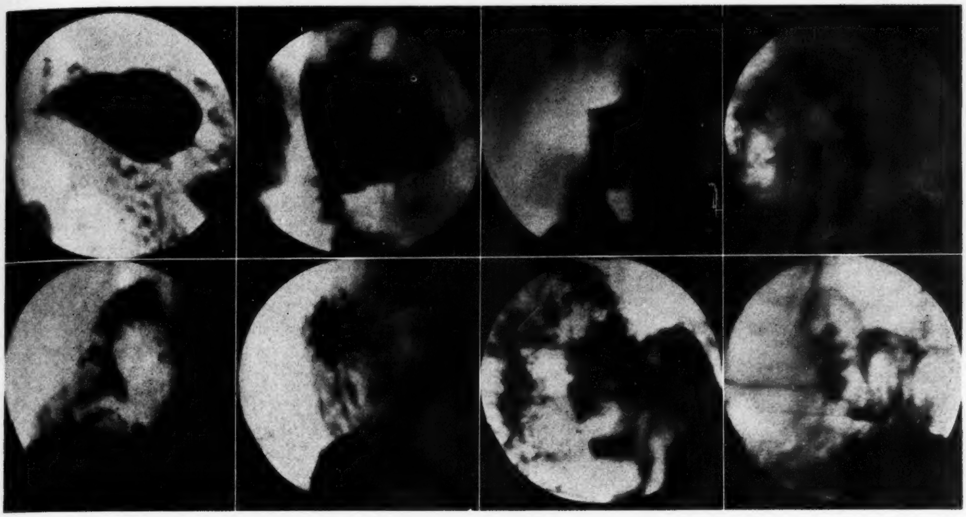
[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.



*(Upper row, reading from left to right.)* Fig. 1. Normal duodenal bulb as seen by the new method, in the right anterior oblique diameter.

Fig. 1-*A*. Normal duodenal bulb in the left anterior oblique diameter.

Fig. 2. Profile niche due to duodenal ulcer of the anterior wall; biconcavity of the surroundings; retraction of the posterior wall; eccentric pylorus.

Fig. 2-*A*. Front niche of the same ulcer in the first oblique diameter, surrounded on one side by a "halo," due to swelling of the mucosa. Dosified compression.

*(Lower row, reading from left to right.)* Fig. 3. Profile niche of the posterior wall with biconcavity of the surroundings and retraction of the anterior wall.

Fig. 3-*A*. Relief niche of the same ulcer with convergence of foldings toward the ulcer (folding star) due to cicatrization. Dosified compression.

Fig. 4. Relief niche with convergence of foldings and marked retraction of the greater curvature.

Fig. 4-*A*. The same niche with star of foldings as seen on increased compression.

In 64 of the above cases, in which a resection of the bulb was performed, the bulbs, *ex corpore,* were filled with barium and plates were taken. In every case the radiologic niche coincided absolutely with the pathologic-anatomic niche. In one case the operation revealed an ulcer which was not diagnosed radiologically, but, on the other hand, in several other cases operated on, in which the X-ray diagnosis was negative for ulcer, operation also failed to show that lesion.

Particularly interesting are those cases in which neither inspection nor palpation during the operation could elicit any suspicious signs of ulcer in spite of the positive roentgenographc findings. However, in every one of these cases, resection confirmed the radiologic diagnosis.

In the Frankfort clinics, with the Berg method, the diagnosis of duodenal ulcer holds by far the most eminent place among gastro-intestinal diseases. It has, as a matter of fact, entirely supplanted the once favorite and time-honored diagnosis of gastric neurosis. Albrecht is also of the opinion that the method of Berg is a far more reliable means of diagnosing duodenal ulcer than inspection and palpation during laparotomy.

From my own experience, I may state that, for the last 20 months, since I have employed the method of Berg, I have been able to demonstrate sure and objective signs of duodenal ulcer with much greater frequency than in the preceding years of my radiologic experience. Since I have been using Berg's method, the gastro-intestinal

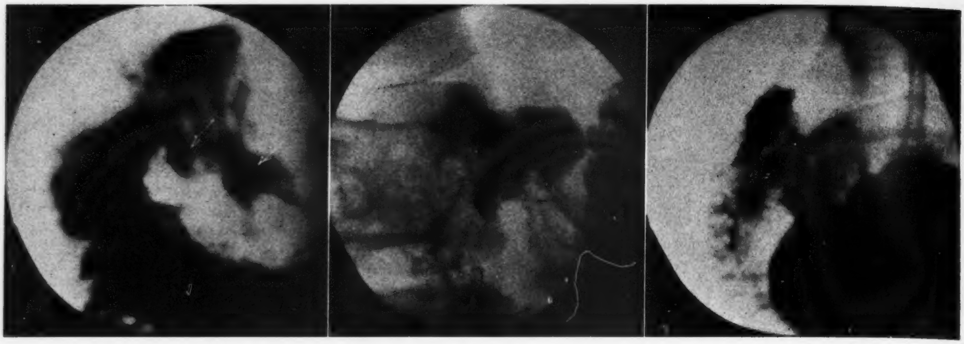


Fig. 5 *(left)*. Relief niche of ulcer behind the pylorus with convergence of foldings toward the ulcer.
Fig. 6 *(center)*. Deformity of duodenal bulb due to converging scar formation, as seen in Figure 6-*A*.
Fig. 6-*A* *(right)*. Star of foldings without actual ulcer; shortening of the bulb.

tract has been examined in 294 cases and duodenal ulcers found in 107. Of these, 79 were severe and 28 suspicious only. Of the 79 cases, 66 showed the classical symptoms of acute duodenal ulcer. Thirteen presented chronic deformities, due to scars. Among the cases diagnosed by the Berg method, a few operated upon proved to be ulcer of the duodenum. The number of such cases is, however, limited, owing to the modern conservative method of treatment, which is gaining ground steadily, thanks to this very method which helps us to diagnose the ulcer much earlier. I claim that the signs seen in the X-ray films correspond exactly to Berg's objective signs, and that an adequate technic helps to detect them without fail. Of course, it is understood that the radiologist has to be experienced in fluoroscopic work sufficiently to distinguish between:

1. A slow peristaltic wave and a constant retraction.
2. A constant niche and a mass of barium retained between the normal foldings of the mucosa.
3. A normal recess and a duodenal pouch caused by dilatation.
4. A deformity due to internal defects and one due to external compression or simple peristalsis.

And now let us turn to the signs and terminology as postulated by Åkerlund and Berg. In order to comprehend them, we must say a few words regarding the various forms and normal contours of the duodenal bulb. Since on leaving the pylorus the bulb turns backward, it is necessary to move the patient in the right anterior oblique diameter, which enables us to observe the bulb anteriorly (Fig. 1). We observe in this position two convex borders, known as the greater and lesser curvatures, corresponding to the terminology applied to the curvatures of the stomach. The two recesses form sort of physiologic pouches, in which we find frequently a slight retention of barium, but this is not to be confounded with a niche. Now in order to see the bulb in profile, we have to turn the patient in the left anterior diameter. In this position (Fig. 1-*A*), we observe normally a change of direction of the axis of the bulb upward and to the left. Its contours, which correspond now with the anterior and posterior walls, have the same convex form as in the previous position.

We know that duodenal ulcer is generally found on either the anterior or the posterior

wall. In this left anterior oblique diameter the niche, therefore, which is the direct objective symptom of duodenal ulcer, has to be found as a "profile niche" (Figs. 2 and 3). The persistence of the niche, or its reappearance during the phases of duodenal contraction, as observed in fluoroscopy, leads us to differentiate between normal transient irregularities and deformities resulting from adherent periduodenitis.

The pathologic-anatomic study of the ulcer reveals that we do not have merely to deal with a niche in the duodenal wall, which could play the part of a receptacle not only for the barium but for any other meal, or even mucus. What is of the utmost importance to us is to make sure that this niche is surrounded by a zone of inflammation, producing a swelling of the mucosa which will be seen as an elevated border, circumscribing at times the whole lumen of the bulb and leading eventually to a stricture. This stricture, although of a transitory character, exerts its influence by dilating the recesses and transforming them into big atonic pouches, known as "false diverticula."

To confirm the existence of ulcer, we have to find the corresponding radiologic signs seen in profile. The swelling of the mucosa prevents the barium from filling the bulb, as a result of which this latter loses its convexity. The biconcavity of the area immediately surrounding the ulcer thus forms the second radiologic sign of duodenal ulcer (Figs. 2, 3, and 7). Taken by itself, this biconcavity would lead one to suspect an ulcer, since it cannot fill with barium because mucus or food remnants are present. With one of the recesses obstructed by swelling of the mucosa, the physiologic pouch loses its convex form, producing an eccentric pylorus as another symptom of duodenal ulcer (Figs. 2, 3, and 7).

An incomplete obstruction of the superior region of the bulb interferes with its complete emptying, leading to constant filling. This condition having lasted for some time, we find the recesses dilated, forming pathologic pouches which are frequently superimposed on the pylorus.

Fig. 7. Duodenal stenosis due to an ulcer which is visible as a front niche, accompanied by severe swelling of the mucosa and deformity of the bulb, an eccentric pylorus, and a small pouch or posterior recess.

As the swelling of the mucosa may extend around the whole lumen of the bulb, the wall opposite to the niche may also lose its convexity, producing the so-called retraction (Figs. 3 and 7).

In multiple ulcers, we frequently find the type of "kissing ulcers," which represent niches with a biconcave profile in the two walls.

Having encountered these signs in profile, we have next to look for their corresponding frontal aspects, therefore, we put the patient in the right anterior oblique diameter. We will find the ulcer an *"en face* niche," also called "front niche" or "relief

niche," *i.e.,* a spot of barium, without any manipulation, when a stricture prevents proper filling of the bulb. When, however, the bulb is well filled, we cannot see this spot, its shadow being covered by the shadow of the bulb (Fig. 4). Dosified compression by Holzknecht's spoon, or by the pneumatic compressor of Chaoul, or by the compressing diaphragm of Berg, has then to remove all the superfluous barium (Fig. 4-*A*).

This compression enables us to see the foldings of the mucosa, among which is to be observed the retention of barium within the niche in the form of a black shadow, which very often will be surrounded by a clear zone (halo) representing the elevated border of the ulcer, due to swelling of the mucosa (Figs 2-*A* and 3-*A*).

When the ulcer has reached the cicatrization stage, we find the interesting phenomenon of the "star of foldings," foldings converging towards the niche (Figs. 3-*A*, 4, 4-*A*, 5, 6, and 6-*A*). We also find the circular swelling of the mucosa around the lumen of the bulb, presenting the appearance of concave retraction of the contours (Fig. 2-*A*).

Here we have all the radiologic signs, which, taken together, prove definitely the existence of a duodenal ulcer. The more of these signs that are found together, the greater is the certainty of our diagnosis. For certain reasons (obesity, adhesions, dislocations, etc.), we cannot always expect to find all of them in every individual case. On the other hand, there are many cases which present them all.

I do not intend to enter into a detailed discussion of the differential diagnosis of every one of the above signs. Naturally there always exist possibilities of error for every one of them. But we must repeat that theoretic knowledge and practical experience permit us to exclude and avoid the errors. The precise limits at which we can arrive in our security of excluding these errors were shown by Berg's statistics in the beginning of this paper.

And now a few words about the so-called chronic cicatrizing ulcer and its relationship to the surrounding organs. There are a number of cases in which neither radioscopy nor surgical intervention will reveal a niche. However, these present another sign, enabling us to diagnose chronic recurrent ulcer, although the patient may not be suffering from any of the typical symptoms of an acute ulcer. I am referring to the shortening of the bulb, brought about by a longitudinal contraction of the cicatrices following a healed ulcer (Figs. 6 and 6-*A*). The periodicity of the ulcer is a well established clinical fact. Each one of these ulcers may leave behind a more or less extensive cicatrix, which may produce an irreparable shortening and deformation of the wall. The gradual approach of the genu superius to the pylorus may even lead to a complete disappearance of the bulb. This observation is of the utmost importance to the surgeon, since it helps to diagnose the approximation of the biliary tract to the region of the ulcer and to resolve the possibility or impossibility of a complete resection.

The co-existence of all of the above described radiologic signs corresponds to an anatomic diagnosis. There are, besides, certain other signs, but of lesser importance, as they are found not only in ulcers but in other conditions as well. These are:

1. Unilateral concavity of one contour.
2. Dislocation of the site or of the axis of the bulb.
3. Loss of mobility of the bulb, owing to adhesion to the surrounding structures.
4. Retrofixation and lateral doubling of the duodenum.
5. Pain on pressure.
6. Too rapid emptying of the bulb; slow-

ing down or lack of peristaltic movement with dilatation of the bulb (megabulb).

7. Swelling of the periduodenal lymphatic glands.

8. Inflammatory swelling of the mucous foldings of the stomach and duodenum.

9. Granulation of the mucous foldings by droplets of mucus (duodenitis).

10. Insufficiency of the pylorus.

The absence of direct radiologic signs should be a contra-indication to operation. When the radiographic data of the duodenum change from one film to another, *i.e.*, in the absence of constancy of the signs as described above, duodenal ulcer should be excluded. Berg sees indication for operation in chronic ulcers with relapse and with tendency toward deformation, strictures, formation of duodenal pouches, and shortening. When one waits too long, the approximation of the surrounding organs may render impossible the radical resection of the diseased area, and may undo the effects of a palliative operation by the appearance of a post-operative ulcer, which, in our actual experience, is so frequent.

## SUMMARY

We have demonstrated the existence of objective signs in radiography of duodenal ulcer. These are:

1. Constancy of the niche found both anteriorly and in profile.

2. Biconcavity of the surroundings of the niche, as seen in profile.

3. Halo around the ulcer, as seen anteriorly. (No. 2 and No. 3 are due to swelling of the mucosa around the ulcer.)

4. Retraction, *i.e.*, loss of the convexity of the wall opposite to the ulcer.

5. Convergence of the folds of the mucosa toward the niche in the form of a star.

6. Duodenal pouch, due to narrowness produced by the swollen mucosa.

7. Shortening of the whole bulb, accompanied by deformity.

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*X-rayed Muscle Loses Hydrogen.*—X-raying living tissue apparently disturbs its respiration in such a way as to drive out hydrogen, and the loss of this hydrogen is probably largely responsible for the death of the tissue.

This discovery was made by V. Everett Kinsey, of the Westinghouse Research Laboratories. He X-rayed pieces of normal human muscle and of cancerous tissue removed in surgical operations, keeping his specimens in a specially built glass vessel to collect for analysis the gases given off. He found that hydrogen, not normally a by-product of respiration, is given off when either healthy or diseased tissue is X-rayed.

Mr. Kinsey has reported his experiments in the English scientific journal, *Nature.—Science Service.*

# THE TECHNIC OF STEREOFLUOROSCOPY

By JESSE W. M. DuMOND, B.S., M.Sc., E.E., Ph.D.
California Institute of Technology, Pasadena, California

*Abstract.*—The problem of obtaining the impression of stereoscopic relief on the fluorescent screen is discussed and the probable field of application of the stereofluoroscope is indicated. Probable reasons for the delay in the practical development of this highly desirable instrument are found to reside in faulty or inadequate solutions of detailed problems, arising in the design of various elements of the apparatus, rather than in the general principle. After a brief history of the author's connection with the problem, there follows an analysis of the geometry of stereofluoroscopic image formation. The article concludes with a detailed description of the author's design of stereofluoroscope, based principally on the model recently constructed for Dr. Opie and now under test at Henry Phipps Institute in Philadelphia. The author has applied for patents based largely on this model and hopes to conclude arrangements for its manufacture in the near future.

## 1. THE PROBLEM OF STEREOFLUOROSCOPY

*The Field of Application Defined.*—The impression of plastic relief afforded by the stereoscopic effect incident to binocular vision has long been an advantage available to the doctor in roentgenography. No instrument now on the market, however, gives this effect on the fluoroscopic screen, though a number of patents[1] have been granted covering various ideas for accomplishing this.

Stereofluoroscopy and X-ray stereophotography must not be thought of as competitive technics. Distinctly different fields of application are indicated for them. In the opinion of the author, the use of the stereofluoroscope is indicated when the advantages of observing natural motions are emphasized, or when the delay incident to the photographic method is undesirable, or when the expense for photographic materials is prohibitive.[2] In addition, the instrument about to be described offers the further great advantage of permitting accurate measurements to be made to scale with calipers which can be directly inserted into the image of the body being examined. As the image appears in the empty space in front of the fluorescent screen to exact scale, it is an easy matter to insert calipers into apparent contact with various features in the image, permitting accurate measurement in any direction, including depth. With the instrument here described, the effort of eye accommodation is also somewhat less than in the stereophotograph. This is due to the fact that the positions of the two images to be viewed are maintained automatically correct. Also, it is due to the further fact that the muscles of accommoda-

[1]The field of stereofluoroscopy is represented in the U. S. Patent Office by about seven patents, including some which have been assigned to prominent manufacturing companies. Of these seven, four have expired. For reasons unknown to the author none of these has been developed and made available to the medical profession in spite of what appears to be a keen interest and strong demand on the part of doctors for such an appliance. To avoid the stigma of not giving credit where it is due, the author appends a list of some previous patentees. The basic idea was patented in 1900. It consists in using two X-ray sources, alternately emitting X-rays and throwing alternate fluoroscopic shadow images of an object from two slightly different viewpoints on a fluorescent screen, with a synchronous shutter mechanism permitting each eye to see the image from one source only, the images being thus different for the two eyes. This patent has long since run out; thus the basic principle has become public property. The list of patentees is as follows:

| | | | |
|---|---|---|---|
| 731287 | J. M. Davidson | 1900 | (Basic principle) |
| 688458 | E. W. Caldwell | 1901 | |
| 733756 | H. C. Snook | 1903 | |
| 758117 | H. C. Snook | 1904 | |
| 1250093 | W. D. Coolidge | 1917 | (Assigned to General Electric Co.) |
| 1390250 | M. B. Rodriguez | 1921 | |
| 1735726 | F. Bornhardt | 1929 | |

[2]The author was recently consulted as to the possibility of using fluoroscopy for the examination of a very large number of cases for a statistical study which would involve too great an expense if large films had to be taken in each case.

tion which focus each eye for the distance of the eyes from the source of light are not required to depart so far from their habitual agreement with the muscles that control the convergence of the pupils in examining one and the same object with the two eyes.

On the other hand, the stereofluoroscope suffers from the obvious disadvantages incident to all fluoroscopic work. Since the light from the screen is faint, the yellow spot at which visual acuity is great in the retina of the observer's eyes cannot be used effectively. The rest of the retina, though very sensitive to faint light, is of but little use for seeing fine detail. Moreover, a considerable period elapses after exposure to ordinary daylight before these parts of the retina attain their full sensitivity. Obviously none of these disadvantages is eliminated or can be expected to be eliminated by the addition of the stereoscopic feature to fluoroscopic work.

In the author's opinion, then, the field for the stereofluoroscope will probably be in emergency work, extracting foreign bodies, setting fractures, barium meal examinations, pelvic and other measurements incident to obstetrics, and all cases in which objects to be observed have sharp outlines and not too fine detail, the observation of motions in plastic relief is desirable, and accurate and expeditious measurements in any direction, including depth, are desired. There is a possibility that the stereofluoroscope will prove advantageous in chest diagnosis for tuberculosis. This possibility is now being investigated at Henry Phipps Institute, Philadelphia, under the direction of Dr. Opie. Little can be hoped for with stereofluoroscopy in cases in which fine detail is sought, or when the outlines of objects are only diffusely or faintly defined.

*Basic Principle.*—The earliest patent (1900) of a stereofluoroscope was based on the same general principle adopted independently by the author. In his opinion, this principle is the most practical one. Two sources of X-rays, placed with a lateral separation of about the average human interpupillary distance, project alternately and intermittently on the fluorescent screen their respective images of an object to be studied. The images are viewed by the two eyes of the observer through a synchronized shutter which permits each eye to see only one of the two images (a different one for each eye). The shutter must, of course, keep in perfect step with the alternate, intermittent emissions from the two X-ray sources. The frequency of the impulses should be sufficiently rapid to insure the impression of continuous illumination in virtue of the "persistence of vision."

*Probable Causes of Delayed Development.*—Even at this late date no stereofluoroscope is manufactured for doctors' use. This is surprising in view of the large number of patents that have been granted and the demand for such an instrument. The following possible causes may, perhaps in part, explain why previous ideas have never been developed for use.

1. There is a popular belief that the fluorescent screen responds to X-ray stimulation, subsiding after such stimulation with a certain large delay which would make the rapid intermittent illumination of the screen impracticable. This belief is wholly incorrect. If a screen be excited by X-rays from a self-rectifying tube connected to an alternating current source, the sharply defined, successive short periods of alternate illumination and darkness can readily be observed by anyone who will take the trouble to turn his head quickly so that his direction of vision sweeps rapidly past the illuminated screen. The time-lag involved in true fluorescence (not phosphorescence) is so short that it has not yet been measured by the most refined methods.

2. From discussions with persons who have seen earlier stereofluoroscopic models,

the author concludes that these did not maintain very satisfactory synchronism between the eye shutter and the X-ray sources. They fell out of step easily and became "dephased" in an annoying way. In the present state of electrical engineering, this difficulty is easy to overcome, especially with the type of direct driven shutter conceived and developed by the author. Some previous patents show shutters operated through long flexible shafts (such as are used to drive dentists' drills) and some of the synchronization and phasing difficulties may have, perhaps, arisen from this cause.

3. A careful examination of all previous stereofluoroscope patents shows not one which is provided with a really practical, compact, and convenient eye shutter designed to meet the various physical and physiologic requirements. The author believes the small cylindrical eye shutter here described to be far better adapted to its purpose than any of the previous rotating discs or vibrating vanes.

4. Most previous stereofluoroscopic models show two separate X-ray tubes as the two sources. Now it is well-nigh impossible to design an X-ray tube with a sufficiently small diameter to permit placing the two focal spots at the average human interpupillary distance. The Phillips tube, manufactured by Müller, with a metal waist-line, comes nearest to this, but it does not completely achieve it. Serious electrical difficulties arise in the design of an X-ray tube of such small diameter. On the other hand, if the focal spots of the two X-ray tubes are placed very much farther apart than the interpupillary distance, a very objectionable distortion is introduced into the stereoscopic image. There is no such thing as an X-ray lens, or mirror, for radiation of the hardness desirable in fluoroscopy. Moreover, enough is now known by physicists about the nature of X-rays, atoms, and the nature of the interaction of these two to say with comparative assurance that X-ray lenses and mirrors, in the ordinary optical sense of these terms, are forever an impossibility. There remains, therefore, in the author's opinion, only one practical solution—to put both the sources of X-rays inside one tube. That this has never before been done in a practical way is perhaps an important contributory reason for the retarded development of stereofluoroscopy to this late date.

5. Finally, there seems to have been little, or no, realization on the part of constructors of previous stereofluoroscopes of the possibility of making precise measurements on the stereofluoroscopic image. Neither has there been devised a simple and practical method of maintaining the geometric relationships between the various instrumental elements and the eyes of the observer, necessary to insure exact scale, or, at least, to minimize distortion.

### BRIEF HISTORY OF THE AUTHOR'S CONNECTION WITH THE PROBLEM

Late in 1929 the need for stereoscopic vision in connection with fluoroscopy was first called to the attention of Archer Hoyt, Ph.D., the author's collaborator and assistant, by John Chapman, M.D., radiologist of the Pasadena Hospital. The solution outlined under the paragraph entitled "Basic Principle" occurred immediately to the author,[3] and he and Dr. Hoyt, with the assistance of Mr. C. Brandemeyer, constructed a crude model with a disc-type shutter which gave sufficient promise of success to warrant developing the idea further.

The next model built was provided with a cylindrical shutter very similar to the latest model. In November, 1930, this stereofluoroscope was first publicly exhibited to the Radiological Society of North America at the California Institute of Technology, Pasadena, on the occasion of the presenta-

[3]The author was not aware of the previous work that had been done in the application of the basic principle described. He did not learn of the patent dated 1900 until some time later.

tion of the Society's medal to Dr. R. A. Millikan. The new stereofluoroscope aroused much favorable comment and a short time later, through the intercession of Dr. Millikan, funds were made available by the Rockefeller Foundation for the development and construction of the first practical realization of the stereofluoroscope for research purposes. It was arranged that the new model should become the property of the Henry Phipps Institute, of Philadelphia, to be tested there under the direction of Dr. Opie. The sum of $4,000 was set aside for the purchase of materials and to compensate Dr. Hoyt for the actual labor of development and installation of the instrument. The work of construction, which was started in August and completed in October, was almost entirely performed by Dr. Hoyt, under the direction and supervision of the author. As the work progressed, various ideas and improvements were added to the instrument. The entire expense, including all materials, the cost of the Wappler Junior Vertical Fluoroscope, which was remodeled, the time of Dr. Hoyt, together with his travelling expenses, and the freight on the instrument totaled $3,000 only. This does not, of course, include any charge for the author's contributions of his ideas and time. The instrument has been installed and is, we believe, coming fully up to our expectations in its performance.

In the Opie model, two small-diameter Phillips-Müller X-ray tubes were used, instead of the two targets in one bulb. This was done to save the time of experimentation incident to the development of the new double-source tube, as it seemed desirable to get one model ready for testing and research with minimum delay.

### DESCRIPTION OF THE STEREOFLUOROSCOPE IN ITS LATEST STATE OF DEVELOPMENT

*General Theory.*—Referring to the plan view (Fig. 1), $X_L$ and $X_R$ are two X-ray sources spaced at the average human interpupillary distance of 65 millimeters. $S$ is the fluorescent screen (seen on edge) and $E_L$ and $E_R$ are the left and right eye positions of the observer. The two X-ray sources will cast on the screen two shadows, $L$ and $R$, of a point object placed at $O$ (such as a small lead bullet). The shadow $L$ cast by the left-hand X-ray source and the shadow $R$ cast by the right-hand X-ray source do not, however, appear simultaneously on the screen. The X-ray sources are energized alternately by the cycles of alternating voltage applied to them so that first $R$ is present, then $L$, and so on at the rate of 50 alternations per second if the frequency of the power supply is 50 cycles per second. The small synchronous motor is driven from the same power supply and, being of the four-pole type, its shaft makes one-half revolution every cycle. The cylindrical shutter is pierced with two pairs of diametrically opposed rectangular holes—one pair for each eye. The axes of the two pairs of holes pass through the cylinder mutually at right-angles. Thus every quarter revolution one eye is obscured and the other permitted to see the screen. When the motor is adjusted in proper "phase," the right eye is permitted to look during the entire interval that the shadow $R$ of the object cast by the right-hand tube is visible on the screen. It is obscured during the interval that the shadow of the object cast by the left-hand tube is visible. By these means the right eye is permitted to see only $R$ and the left eye is permitted to see only $L$. The observer interprets the position of the image to be at $I$, since the light comes to the two eyes exactly as it would if the object occupied the position $I$.

*Symmetric Case with Distortionless Image.*—Now it is easy to see that, if the screen is just midway between the eyes and the X-ray sources, and if the inter-focal distance of the sources equals the interpupillary distance of the eyes, the position of the

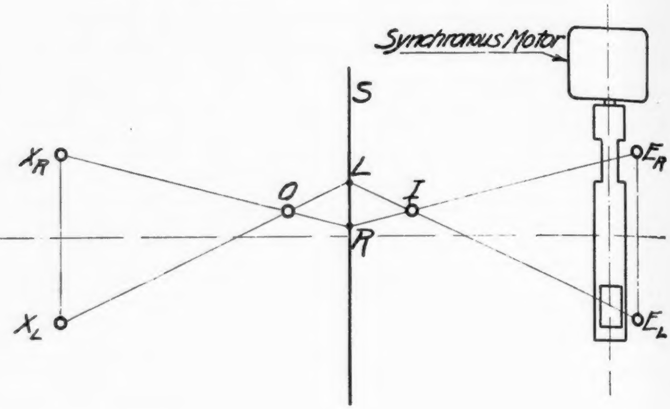



Fig. 1 *(top).* Diagram illustrating the principle of the stereofluoroscope (symmetric case).

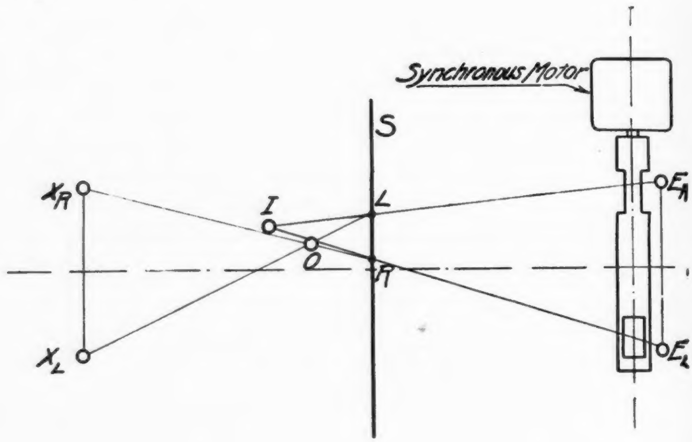



Fig. 2 *(center).* Diagram illustrating the stereofluoroscope (asymmetric case).

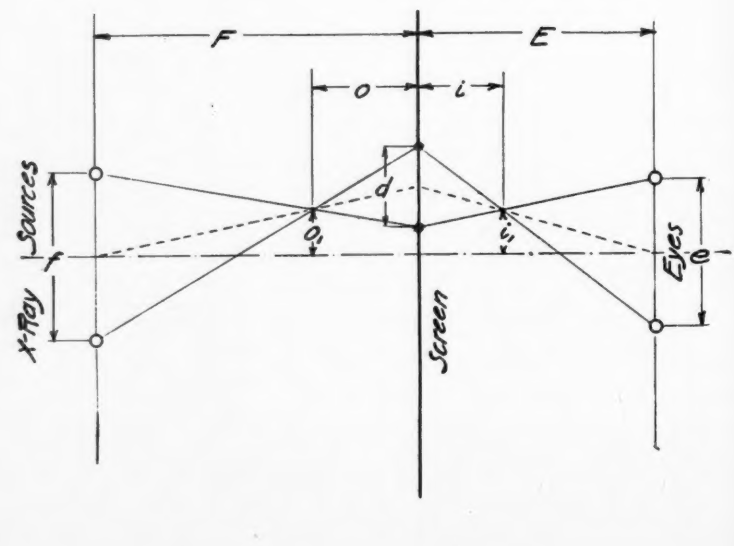
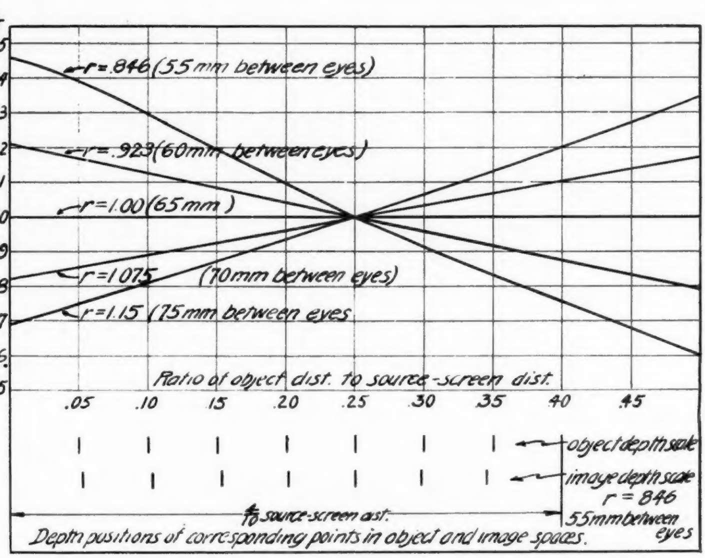



Fig. 3 *(bottom).* Diagram used in analysis of stereofluoroscopic distortions.

image $I$ will be just as far in front of the screen as the object $O$ is behind it. Further, the image $I$ will be just as far to one side each and all of which the above statements apply. It follows that any object whatever will have a stereoscopic image in front of



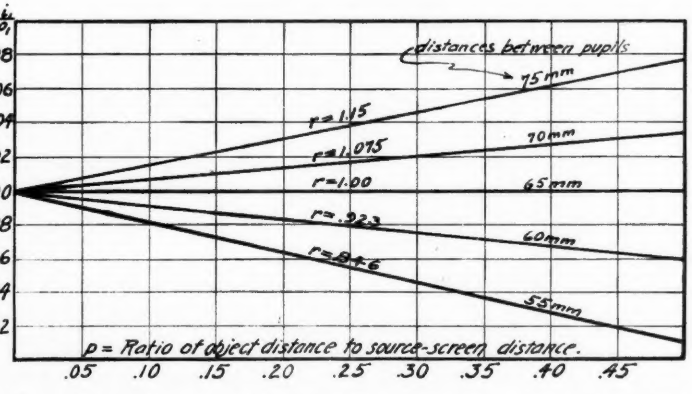




Fig. 4 *(top)*. Curves of minimized depth distortion for various interpupillary distances. Note that, even in the most extreme cases of interpupillary deviation from normal, the errors introduced are less than 5 per cent.

Fig. 5 *(bottom)*. Curves of lateral distortion for various interpupillary distances. This distortion consists of a simple change of scale, uniform over the entire lateral field of view, but varying with distance from the screen. (Both distortions can be completely eliminated, if desired, by the introduction of two small optical devices on the shutter which compensate for the interpupillary deviation from normal.)

of the central axis as the object $O$. A more complicated object may be considered to consist of an assemblage of such points, to the screen *which will be an exact scale reproduction of the object* mirrored in the screen. Posterior points of the object appear as an-

terior points of the image. This is the geometry of the simple distortionless image. For brevity we shall refer to this as the "undistorted symmetrical case."

*Asymmetrical Case.*—What will happen if the phase of the shutter is shifted so as to permit the right eye to see only the image cast by the left tube and the left eye only the image cast by the right tube? It is evident (Fig. 2) that in this case the image point, *I*, will appear to be behind the screen and it will *not* be in the position of the object point *O*. Thus the image of a complex object will suffer distortion. It will, however, not be related to the object as though mirrored in the screen. Posterior points of the object will appear as posterior points in the image and anterior points of the object will appear as anterior points in the image. For brevity we shall refer to this as the "asymmetrical case." It is always distorted.

The symmetrical case is sometimes referred to as the "pseudoscopic image," the asymmetrical case being then referred to as the "stereoscopic image." We prefer not to use this terminology, because it suggests greater desirability or validity for the asymmetric case when, in fact, we believe the symmetric case to be the more desirable of the two. The very slight difficulty of interpretation caused by the reversed postero-anterior relation of the symmetric case seems to us to be far outweighed by the enormous advantage it offers of giving an image in perfectly accurate scale relation to the object. The reader should note that, in the symmetric case, the image suffers no error whatever from the divergence of the X-ray beams.

A small knob attached to the far end of the rotating shutter permits the observer to shift the phase of the shutter so as to give either the symmetric or asymmetric case. The observer, while looking through the shutter, applies just sufficient friction to this knob with his thumb and forefinger to cause the synchronous motor to "slip" one pole, that is to say, one-quarter revolution. It is extremely easy to distinguish which of the two cases is being viewed, for, in the symmetric case, the image appears to occupy the empty space in front of the screen and the observer can stretch out his hand and appear to "touch" the image (though, of course, no sensation save that of sight is involved). In the asymmetric case, the image is inaccessible to the hand of the observer as it appears to be behind the screen.

*Analysis and Minimization of Distortions Caused by Abnormal Interpupillary Distances.*—We now pass on to discuss the symmetric case when the distortionless condition described above is not quite fulfilled. Different individuals differ slightly in their interpupillary distances, the range being from about 55 to about 75 mm. in extreme cases. With two separate X-ray tubes as the two sources, it is, of course, a simple matter to correct for this by shifting the separation of the tubes to agree with the interpupillary distance of the individual observer. The author believes, however, that a simpler, cheaper, and more practical solution consists in using *one* tube containing two targets and two focal spots separated by a fixed distance equal to the *average* human interpupillary distance and then making a slight correction by means of an optical device near the eyes which gives the eyes a virtual separation equal to the separation of the X-ray focal spots. A strong argument in favor of this solution is, as we have mentioned above, the fact that it is difficult, nay, well-nigh impossible, to design a good X-ray tube of sufficiently restricted diameter so that two such tubes can be spaced with their focal spots separated by the minimum human interpupillary distance, whereas *one* tube can be easily designed to fulfill this condition.

It is, however, important first to inquire whether any geometric relationship among the tube, the screen, and the eyes will *mini-*

*mize* the slight distortion consequent to a deviation of the interpupillary distance of a particular observer from the fixed interfocal distance of the X-ray targets. And, furthermore, it is desirable to determine precisely the magnitude of such minimized slight distortions in the directions of both depth and breadth. These questions are solved by a brief geometric analysis of the problem given here. (The non-mathematically inclined readers may well omit this analysis as it is not essential to an understanding of the stereofluoroscope. The results for a practical case as plotted in Figures 4 and 5, however, have a general interest and should be carefully studied.)

Referring to Figure 3, the significance of the various distances is evident from the diagrams and need not be explained. We define a number of ratios between these distances as follows:

In order that there shall be no distortion we must have $\frac{i}{o} = 1$. For this condition on solving for $\frac{E}{F} = x$ we obtain

$$x = r + p(1 - r) \qquad (2)$$

This x is the ratio of the eye-screen distance to the tube-screen distance which must obtain if there is to be no distortion. It depends on $p_1$, the relative position of the object. Hence it is evident that, for an *extended* object, the distortion cannot be completely eliminated over all parts (except, of course, when $r = 1$). The depth distortion can be minimized to a very small value, however, by choosing a value of x corresponding to a *mean* object position $p^*$ roughly at the center of the extended object, or possibly somewhat beyond the center. Then, when the eyes-screen and tube-screen distances are adjusted to have this ratio, we shall have

$$r = \frac{e}{f} = \frac{\text{interpupillary distance}}{\text{interfocal distance}} \qquad \text{(given)}$$

$$p = \frac{O}{F} = \frac{\text{object-screen distance}}{\text{tube-screen distance}} \qquad \text{(given)}$$

$$x = \frac{E}{F} = \text{optimum value of } \frac{\text{eye-screen distance}}{\text{tube-screen distance}} \qquad \text{(to be found)}$$

$$S_1 = \text{the longitudinal scale ratio} = \frac{\text{small distance in depth of image}}{\text{corresponding distance in depth in object}} \qquad \text{(to be found)}$$

$$S_2 = \text{the lateral scale ratio} = \frac{\text{small distance measured laterally in image}}{\text{corresponding distance measured in object}} \qquad \text{(to be found)}$$

The rays from the two images on the screen to the two eyes cross at the image and form two similar triangles. Also the X-rays from the two tubes cross through the object and form two similar triangles. The base-line, *d*, is common to the two systems. It is easy then to show that

$$\frac{E - i}{F - O} = r\frac{i}{o} \qquad (1)$$

$$\frac{i}{o} = \frac{r + p^*(1 - r)}{r + p(1 - r)}$$

or, with sufficient accuracy,

$$1 + (p^* - p)\frac{1 - r}{r} \qquad (3)$$

where $p^*$ is the relative position of a point near, or a little beyond, the center of the ex-

tended object and $\frac{i}{o}$ refers to a point in the object at the relative distance p.

The scale ratio measured longitudinally is simply

$$\frac{di}{do} = r \frac{x}{[r + p(1 - r)]^2} = S_1 \qquad (4)$$

This is only of secondary interest, however, and is seen to depend on the relative position p in depth in the object.

The scale ratio measured laterally is easily obtained from $S_1$ by the principle of similar triangles. It also depends on the relative position in depth in the object and is given by

$$\frac{i_1}{o_1} = \frac{di_1}{do_1} = \frac{r}{r + p(1 - r)} = S_2$$

or, with sufficient accuracy,

$$1 - p\left(\frac{1 - r}{r}\right) \qquad (5)$$

We now consider five cases of interpupillary distance, ranging from the extreme case of an observer having an interpupillary distance of 55 mm. to the other extreme of one having an interpupillary distance of 75 millimeters. We assume a distance of 65 mm. between the two X-ray source points. We assume that the center of the object is one-quarter as far from the screen as the tubes are, which will be the case for the chest of a patient of about average thickness. (For thinner objects, such as the hand or arm, conditions will be much more favorable.) For these assumed values then we shall have:

| r | p* | x | Interpupillary distance (extreme cases) | Interfocal distance | xr |
|---|---|---|---|---|---|
| 0.846 | 0.25 | 0.885 | 55 mm. | 65 mm. | 0.749 |
| 0.923 | 0.25 | 0.942 | 60 mm. | 65 mm. | 0.87 |
| 1.00 | 0.25 | 1.00 | 65 mm. | 65 mm. | 1.00 |
| 1.075 | 0.25 | 1.056 | 70 mm. | 65 mm. | 1.136 |
| 1.15 | 0.25 | 1.1125 | 75 mm. | 65 mm. | 1.28 |

*Results of Analysis of Minimized Distortion.*—Figure 4 shows a set of curves expressing the minimized depth distortion for various deviations of interpupillary distance from the normal value of 65 mm., at which the focal spots of the two sources are set. Note that the distortion never exceeds 5 per cent. Under the most extreme interpupillary conditions and for very deep objects, the position in depth of a point in the image will not deviate more than a very few millimeters from the position of the corresponding point of the image. The two scales in Figure 4 show conclusively the smallness of the minimized depth distortion, even for a very extreme case (55 mm.) of interpupillary distance. It seems safe to conclude that, when the distortions have been minimized by setting the ratio of eye-screen distance to tube-screen distance at the value $\frac{3}{4} r + \frac{1}{4}$, the depth distortion is completely negligible over a depth extending from the screen to 0.4 the distance to the tubes, r being the ratio of the interpupillary distance to the interfocal distance.

Figure 5 shows the curves of lateral distortion. Since the lateral distortion *varies* with depth to the same degree as the depth distortion, its *variation* is also negligible. The lateral distortion is perfectly uniform over the entire field in the lateral direction. We can, therefore, say that the lateral distortion is *uniform* over the entire field for all practical purposes but *consists of a magnification or minimization of lateral scale of amount* $\frac{i_1}{o_1}$. The lateral distortion is therefore independent of the value of x chosen in order to minimize the depth distortion.

Now by reference to Figure 5 it is evi-

dent that, for an observer with an interpupillary distance of 55 mm., the lateral dimensions of the image will be only about 8 per cent less than natural scale independent of how the depth distortions have been minimized by the proper choice of the ratio (x). Similarly, for an observer with an interpupillary distance of 75 mm., the lateral dimensions will be magnified to about 8 per cent more than natural scale. Both of these figures are for the extreme case of deep objects where p = .5. There is, therefore, no very serious objection to the method of minimizing distortion by adjustment of the ratio between the eye-screen distance and the tube-screen distance, for the correction which minimizes depth distortions introduces no serious discrepancy between the scale of lateral dimensions and the scale of longitudinal dimensions.

There exists an erroneous idea that distortions can be eliminated by choosing the ratio between eye-screen distance and tube-screen distance so as to make the X-ray sources subtend the same angle at the center of the screen as the angle subtended by the eye pupils at that point. This amounts to making x equal to r. The above analysis shows conclusively that such a procedure will not even minimize the depth distortion except for object points in actual contact with the screen. For an *extended* object, such a procedure will not minimize depth distortion all over the object by any means, and it will still introduce the objectionable difference in scale between lateral dimensions and depth dimensions. Nevertheless this erroneous idea seems to be held quite generally and is even mentioned in one patent in the United States Patent Office.

*Alternative Solution to Eliminate Distortion Completely.*—A much better solution, for which the author has applied for letters patent and which may be permanently adopt-

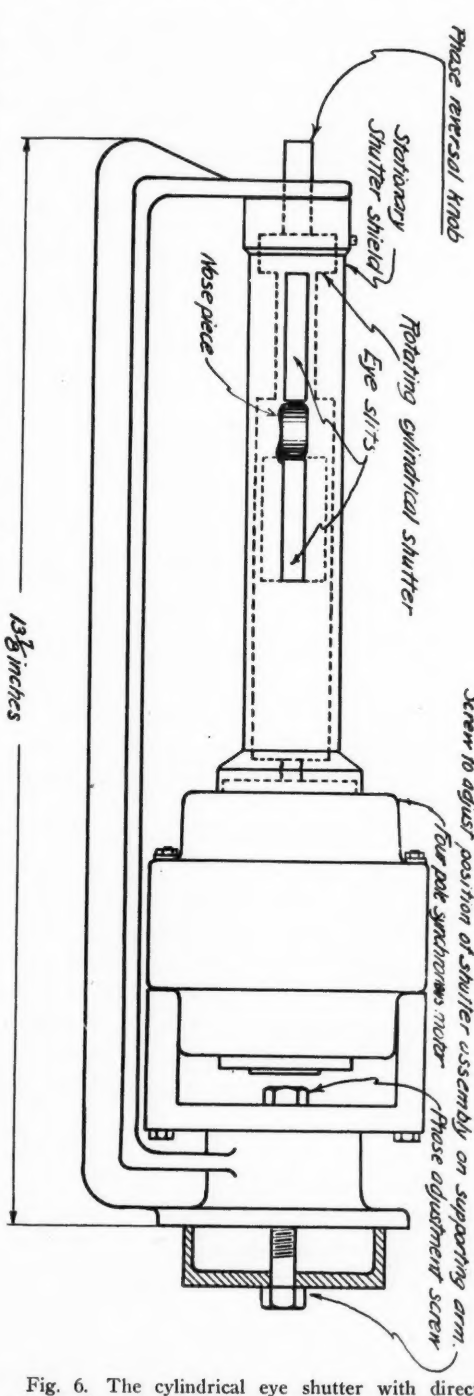



Fig. 6. The cylindrical eye shutter with direct connected synchronous motor. The cylindrical shutter proper is shown inside the shutter shield by the dotted lines.

ed in future designs, is to use a pair of small correcting optical devices attached to the eye-shutter openings to correct for abnormal interpupillary distances. This presents the advantage that all *distortions vanish completely* with its use. By first setting the optical correctors to suit his interpupillary distance, measurements can be made with complete accuracy by any observer with any interpupillary distance whatever. Such an arrangement operates in a manner quite similar to the binocular microscope adjustment for interpupillary separation. With this arrangement, the ratio x is held at unity and the screen is always midway between the X-ray sources and the eyes.

*Even Considerable Distortion not a Serious Disadvantage.*—The preceding detailed discussion of the theory of distortion may lead the reader to attach more importance to this point than it deserves.

For the purpose of measuring absolute dimensions of an organ or skeleton *in centimeters,* obviously distortions must be minimized to the desired degree of accuracy of the measurement. A great deal of stereofluoroscopic examination, however, does not require accurate measurements to scale, depending rather on a study of the *relative* positions of various parts of the object with respect to one other. For this purpose, even much greater distortions can easily be tolerated than those the above-mentioned approximate method gives. The one essential is that there shall be *no very abrupt changes* in distortion throughout the image space. This condition is amply fulfilled even without the use of the above optical correction.

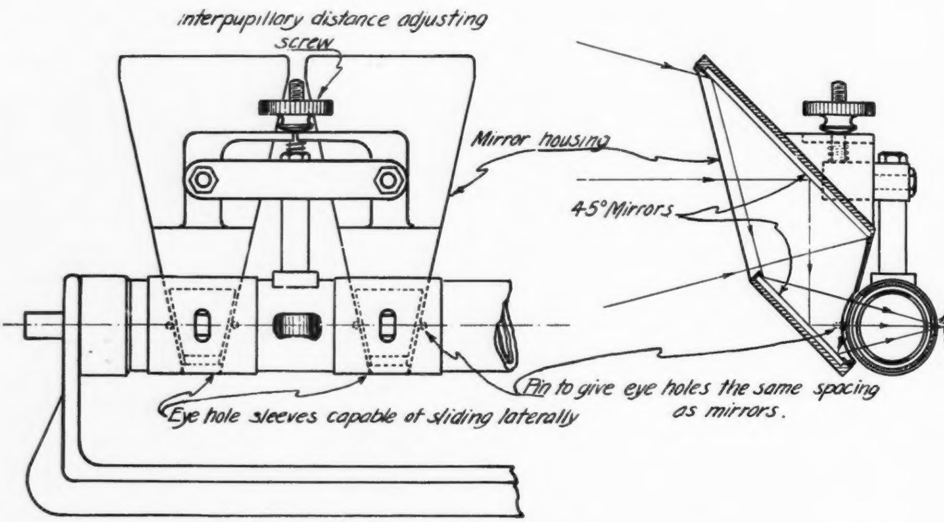



Fig. 6-*A*. Showing one design of interpupillary compensator.

*Detailed Description of the Stereofluoroscope as Developed to Date.*—We will now describe in detail the various elements of our stereofluoroscope that constitute its novelty and give the instrument its peculiar advantages over previous proposed designs. It is, of course, not at all impossible that further improvements or refinements may occur to us; but we feel that we have now reached a stage in the design of this instru-

ment which warrants disclosure and which will probably remain fairly representative of future instruments.

*The shutter* is shown in Figure 6. Enough has already been said above about

*Theory and Technic of Shutter Design.*—The design of the shutter involves the fulfillment of three main requirements.

1. A large angle of vision, both horizontally and vertically, must be permitted.

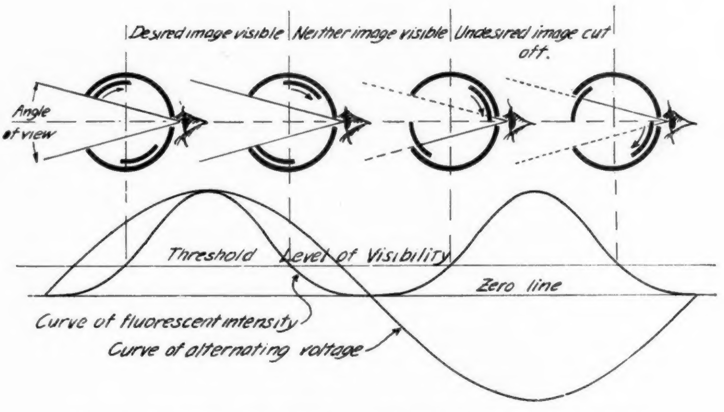



Fig. 7. Diagram illustrating considerations of shutter design.

this element to make the drawing self-explanatory. The cylindrical design presents the immense advantage of easy adaptability to the eyes and the bridge of the nose. It is simple, light, noiseless, vibrationless, and extremely durable. There is nothing to get out of order, as the cylindrical shutter proper is rigidly mounted directly on the shaft of the synchronous motor and the shutter, armature, and shaft form only one moving part which spins freely. The phase adjustment of the shutter (described below) is conspicuously simple and accurate, thanks to the proximity of motor and shutter. A small nose piece is provided as shown, to center the observer's head properly and to prevent parallax errors when the observer is making precise measurements on the stereofluoroscopic image. The phase reversal knob, shown in the diagram, permits the observer to choose either the symmetric image in front of the screen or the asymmetric image behind the screen at will, by a mere touch with thumb and forefinger.

2. The opening and closing of the shutter must be as nearly as possible simultaneous for all parts of the field of view.

3. The shutter must permit the proper image to be seen by each eye *for a maximum fraction of each cycle* (without permitting the wrong image to be seen at all). This is to avoid sacrificing brightness of the object.

A little consideration of Figure 7 will show that all three requirements are best fulfilled by (1) A design which places the eye-pupil as close as possible to the rotating cylinder relative to the diameter of the cylinder; (2) An angular extent of the opaque arc of the shutter no more than just sufficient to obscure the vision of the entire screen during that fraction of a half-cycle in which the intensity of the undesired fluoroscopic image for the eye in question rises above the level of visibility. This we have shown to be, for all practical purposes, independent of the X-ray intensity, since the *visibility* of the unwanted image at the instant of cut-off or opening is a question of

the degree to which the eye has already been excited by the proper images just previously seen. The following method (due to the author) of determining the minimum permissible angle of the opaque arc has been found very practical.

A small sample of the fluorescent screen to be used is glued to a disc (near its periphery) rotating on the shaft of a four-pole synchronous motor which is operated at the frequency to be employed with the stereofluoroscope. Intermittent X-rays, from a tube running under similar conditions to those in the stereofluoroscope, are allowed to fall on the disc with its small piece of screen. There appear then two quite well defined angular regions of the periphery of the disc within which the fluorescence of the small sample of screen is visible. This angle of visibility is measured, the opaque arc of the shutter being designed equal to it.

The feasibility of this cylindrical design of shutter depends on the fact that there are finite intervals of invisibility of the screen between succeeding half-angles during which the illumination is below the threshold of vision as conditioned by the maximum value of the illumination of the screen. If it were not for these effectively dark intervals, the stereofluoroscopic image would not appear to be uniformly brilliant from top to bottom, because of the passage of the opaque shutter arcs into the field of view at the *back* side of the shutter. *It was the recognition of the existence and utility of this effectively invisible interval in connection with the cylindrical shutter design that constituted the most important novel element of invention in it.* The reason for the pronounced duration of invisibility is to be found partly in the fact that the X-ray intensity is approximately proportional to the *square* of the sinusoidal applied voltage. Thus that fraction of maximum tube voltage just sufficient to excite visibility on the screen is not attained until a quite considerable fraction of a half cycle has elapsed after the zero point. The diagram in Figure 7 should make this clear.

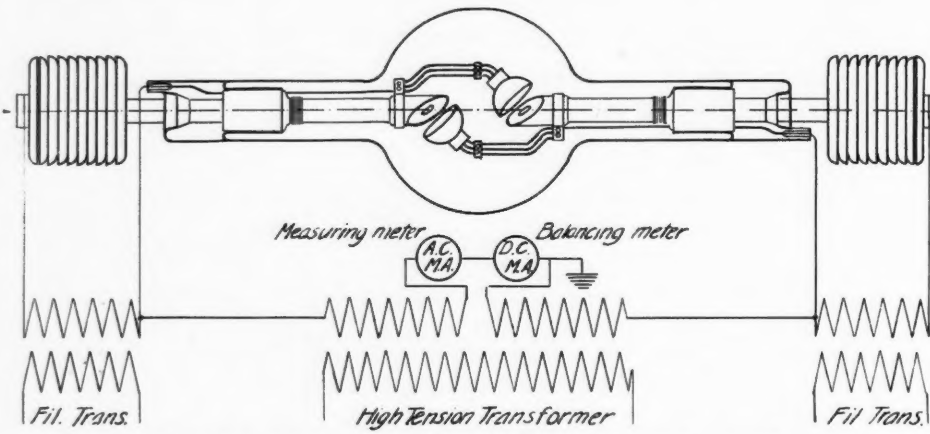



Fig. 8. Design of double source X-ray tube best adapted to the stereofluoroscope.

*Technic of Phasing the Shutter.*—An opaque diaphragm is placed over one of the X-ray sources in the stereofluoroscope so that only the other source can illuminate the screen. The motor is then unclamped by unscrewing its clamping screw, and rotated bodily until the eye on the same side as the obscured X-ray source sees a perfectly dark field all over the screen. This puts the shut-

ter in correct phase, and it is to be clamped in that position. Once phased properly, it remains so indefinitely (save that one has, of course, the choice of either the symmetric or asymmetric case by applying friction to the phase reversal knob). This method of obscuring the X-rays from one tube is far superior to the method of disconnecting one tube electrically for phasing purposes. In the latter case, the consequent dissymmetry of the load shifts the phase of the single operating tube away from that which it will have when *both* tubes are operating.

*The X-ray Source.*—Figure 8 shows the author's design of X-ray tube containing the two X-ray source points in one bulb for stereofluoroscopic work. It is almost completely self-explanatory. Two beveled targets are used, situated on the main axis of the tube and spaced with their focal spots at a convenient distance approximating the average human interpupillary distance. The target faces are nearly, but not quite, parallel to each other. They are turned away from mutual parallelism just enough to permit the cone of X-rays from each focal spot to illuminate its required field on the fluorescent screen. The bell-shaped cathodes are placed as near to their respective targets as possible, consistent with complete illumination of the screen. Each cathode is mechanically supported by a target; one of its filament terminals may be grounded thereto. Press seals are provided through short side teats for the cathode filament connections.

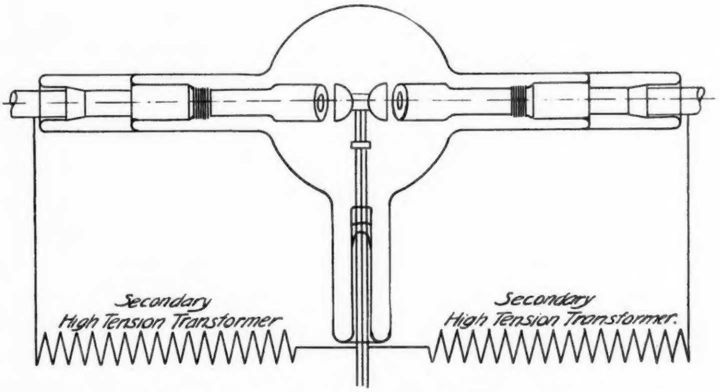



Fig. 9. Alternative design of double source X-ray tube, not as desirable as the one shown in Figure 8, since it requires twice as much voltage of the supply transformer for the same hardness of radiation.

The advantages of this design are:

1. The two focal spots can readily be given the 65 mm. separation equal to the average human interpupillary distance. It is difficult to design two separate tubes of such small diameter in the focal spot region that the focal spots can be given a separation of 65 millimeters. This is principally because of the physical effect known as "cold electron emission" which takes place even in the highest vacua if the radii of curvature of the opposing electrodes are too small.

2. The placing of the two targets and cathodes in one tube effects a very considerable saving in cost to the consumer. It is well known that the parts (cathode and anode) for at least one standard make of X-ray tube now on the market can be obtained for less than fifty dollars, whereas the tube consisting of these same parts, ready to use, inside an appropriately evacuated bulb, costs over two hundred dollars. It is the vacuum which is expensive, or,

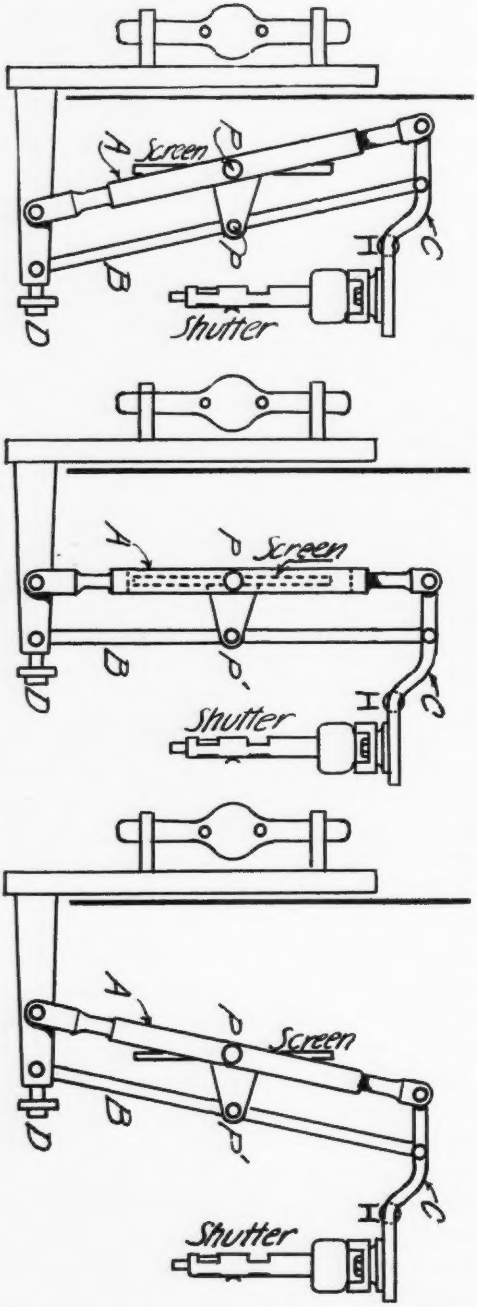



Fig. 10. Schematic diagram of linkage mechanism for screen and shutter mounting maintaining constant, but adjustable, ratio between source-screen and eye-screen distances.

rather, the procedure required to realize the vacuum and render it permanent. Obviously, then, the use of one vacuum for both sources of X-rays effects a great saving in cost.

3. Another design of double source tube for stereofluoroscopic work, consisting of a pair of cathodes placed half-way between two targets (Fig. 9), has been made the subject of a patent in this country. The author's design (Fig. 8) has the advantage that only half as much insulation and half as many turns of transformer secondary winding (the expensive part) are required. In fact, a tube of the type shown in Figure 9, operating on 70 K.V. cathode to anode, requires a transformer capable of giving 140 K.V., while the tube shown in Figure 8, operating on 70 K.V., requires only a 70 K.V. transformer and two filament lighting transformers, which can be cheaply incorporated in the same oil tank.

4. The author's design of double source X-ray tube permits close approach of the cathode to the target face. This is an important technical point. The proximity of the target shields, to a large extent, the remainder of the tube from exposure to the intense heat radiated from the incandescent cathode filament. The proximity of the cathode shields the glass tube envelope from bombardment by electrons reflected and rediffused after collision with the target. (These electrons, if allowed to strike the glass walls of the tube, accumulate there as patches of electrical charge which may result in electrical puncture of the glass.) A better distribution of the electrical stress to which a glass envelope of a given size is subjected can be obtained if cathode and anode are placed closer together. Finally, and probably the most important, the tube will operate on less rigid vacuum requirements if cathode and anode are close together. This is sometimes known as the Hittorf effect. If an electron need only exe-

cute a short path from cathode to anode, the chance of its collision with a gas atom, and consequent production of the gas-tube type of discharge, is proportionately lowered; hence a poorer vacuum can be tolerated be-

with the patient either in the horizontal or the vertical position. Now it is obvious that, when the observer stands in front of the patient in a vertical examination, the eyes and, therefore, the X-ray focal spots of the tube,

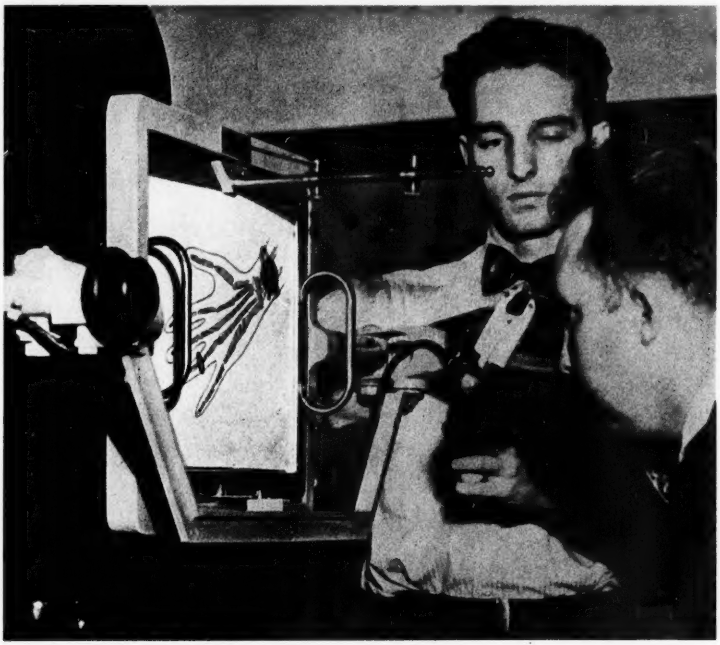


Fig. 11. View of stereofluoroscope constructed for Dr. Opie. Dr. DuMond is seen in profile. Dr. Hoyt is behind the instrument, with his hand in position for examination.

fore the tube becomes inoperative from this cause.

5. A final obvious advantage in the author's design of double source X-ray tube is its adaptability to existing fluoroscopes. With little or no modification, the tube shown in Figure 7 can be mounted in the holders provided for ordinary X-ray tubes. The only electrical modification required is the addition of one insulation transformer for the extra filament of the double source tube.

There seems also likely to be a demand for a stereofluoroscope which can be used

must be spaced apart *laterally* with respect to the patient. In a horizontal examination, the observer stands at the side of the patient and his eyes and, hence, the X-ray focal spots of the tube must be spaced apart longitudinally with respect to the patient. It follows, therefore, that, in changing from vertical to horizontal examination, means must be provided for swinging the X-ray tube assembly through an angle of 90 degrees. It is self-evident that this can be much more easily accomplished with a single tube design than with a design involving two separate tubes.

*The Screen and Shutter Mounting.*—From the discussion of image formation given above, it is evidently important to provide means for maintaining the source-screen distance equal to the eye-screen distance. This could be accomplished quite simply by making a fixed setting of screen and eye shutter were it not for the fact that it is extremely desirable to be able to vary the position of the screen to accommodate the varying thicknesses of the bodies and other parts to be situated behind it. The author's design of screen and shutter mounting permits this geometric condition to be automatically maintained, while permitting freedom of motion of the screen. Furthermore, it automatically maintains the screen and shutter axis each normal to the axis of vision. All this is accomplished with a linkage consisting in essence of only three distinct moving parts.

This fundamental linkage system is shown in plan schematically in three positions (Fig. 10). The link *A* is a frame (seen on edge in the diagram) which completely surrounds the fluorescent screen pivoted to it at top and bottom with two pivots, *P*. The link *B* is shaped so as not to pass across the center of the fluorescent screen, where it would obscure vision, but on the level of the lower edge of the screen. At its center, a stiff projection from the bottom of the screen is pivoted to link *B*, thus maintaining the screen always normal to the axis of vision. The links *A* and *B*, together with link *C*, comprise a parallelogram motion which maintains the eye shutter and motor attached to *C* always normal to the axis of

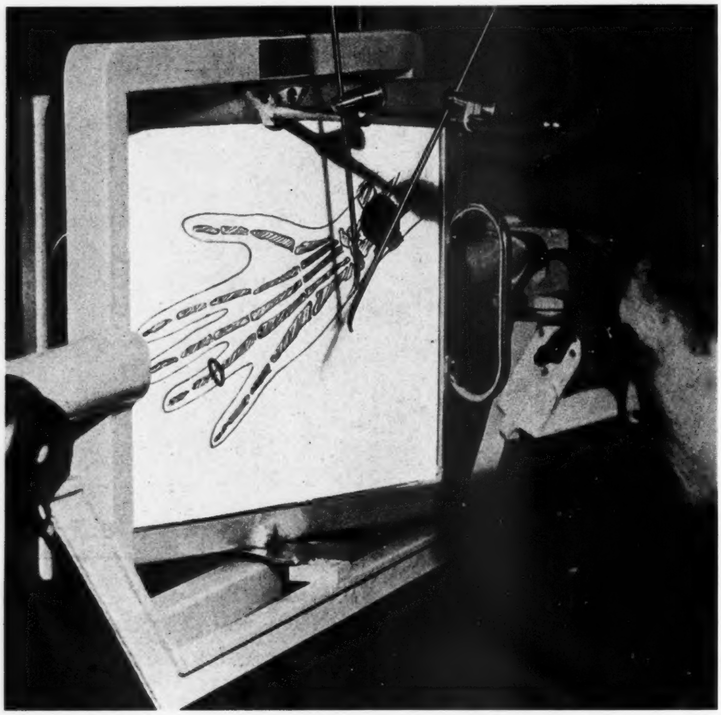


Fig. 12. Another view of stereofluoroscope constructed for Dr. Opie. The image on the screen is a pen-and-ink sketch. The measuring calipers are clearly shown.

vision. The lateral displacement of the eye shutter, due to the angularity of links $A$ and $B$ in their extreme positions, is too small to introduce any appreciable error in practice. A handle, $H$, located on the underside of

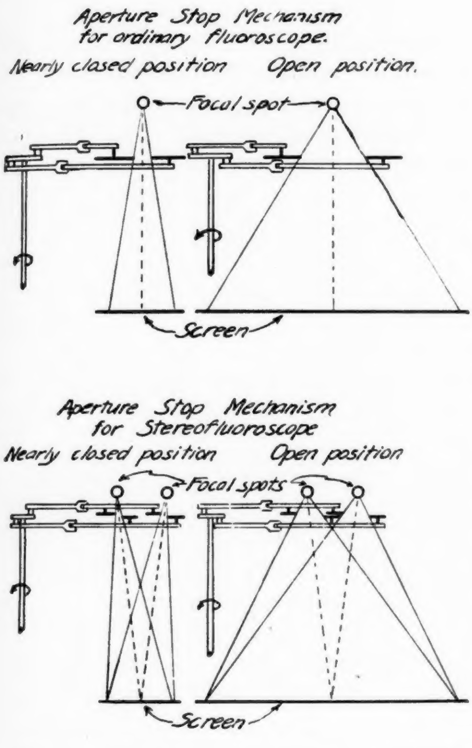



Fig. 13. Illustrating modification in horizontal aperture stop for the two sources essential to stereofluoroscopy.

link $C$, can be conveniently grasped with the right hand to adjust the position of screen and eye shutter. The right hand and the head thus execute similar movements in a perfectly natural way. The left hand remains free to adjust the knobs, $D$, which control the X-ray field aperture stops (Figs. 10 and 11).

After the above description, the advantages of this type of screen and eye shutter mounting need only enumeration. They are:

1. Small number and simple rugged character of moving parts.
2. Adjustability of most general type for minimizing distortion.
3. Screen and eye shutter automatically held normal to axis of vision.
4. Easy adaptability to existing fluoroscopes.

A clearer idea of the entire screen and shutter mounting can be obtained by referring to the photographs, Figures 11 and 12.

*The X-ray Field Aperture Stops.*—Once an object has been located, there is a well recognized advantage in cutting down the port of opening of the X-rays, to improve the clearness of the image. The improved sharpness of image comes about because of the reduction in the amount of stray radiation scattered into the image from adjacent parts of the object.

With the change from a single to a double source required in stereofluoroscopy, the field aperture stop must be modified to provide *two* ports of variable size in front of each focal spot. Ordinarily, the aperture stops consist of two pairs of lead jaws controlling the aperture size in two mutually rectangular directions. When the double source for stereofluoroscopy is introduced, only one pair of these jaws needs modification, namely, the pair the motion of opening and closing of which is parallel to the axis joining the two X-ray sources. The modification consists in introducing, in place of this single pair of jaws, a pair for each focal spot sliding in a plane somewhat closer to the X-ray source than before. The plane of these jaws is placed sufficiently close to the X-ray source so that, when they are wide open, the inner member of each pair does not interfere with the aperture of the other pair. Figure 13 shows schematically the position occupied by these jaws in the ordinary fluoroscope and the way in which this is modified in the stereofluoroscopic adaptation. It is a simple matter to con-

struct jaws of leaded rubber, rather than metallic lead, if the geometry above-mentioned requires them to be so close to the X-ray tube that the proximity of a metal jaw might be hazardous. This general plan of modification has been followed with complete success in the stereofluoroscope constructed for Dr. Opie's use at the Henry Phipps Institute. The same mechanism of links and levers controlling the ordinary aperture stop was used for the double source aperture stop, though a slight modification in the lengths of certain lever arms was made to give the proper modification in the amplitude of travel.

*Electrical and Circuit Problems in Stereofluoroscopy.*—The additional source of X-rays necessary for stereofluoroscopy necessitates some additional electrical equipment, namely, an extra filament transformer, a small rheostat for maintaining balanced intensity of the two X-ray sources, an extra milliameter (as explained below), and possibly the replacement of the ordinary filament control rheostat with one of larger capacity, to handle the power supplied to two filaments instead of one. There arises the problem of measuring the milliampere current supplied to both tubes and of indicating the state of balanced operation so that any tendency for one tube to take more current than the other can be readily observed and corrected. To avoid the danger of shock to the operator, it is, of course, desirable that all metering and control apparatus should be at, or near, ground potential.

The extra filament insulation transformer needs little comment. In a new stereofluoroscope, it is preferably located inside the transformer tank. In adapting an old model fluoroscopic outfit for stereofluoroscopy, the extra filament transformer can be installed as an outside unit. In the Wappler model reconstructed for Dr. Opie, no extra filament transformer could be easily obtained operating on the same primary voltage as the one already in the transformer tank, and so a small autotransformer was installed in the control unit to correct for this.

The balancing control rheostat serves to throw slightly more resistance into the primary circuit of either one or the other filament transformer. As the correction necessary to maintain balanced operation is a small one, only a very small resistance is needed here. The X-ray tube filaments are virtually connected in parallel (through their insulation transformers) to the same source of voltage, and there is, therefore, a benevolent tendency toward stability of balance, due to the positive thermal coefficient of the resistance of the tungsten filaments. Furthermore, for stereofluoroscopy, the requirement of the accuracy of balance of the intensity of the two X-ray sources is not very exacting. (The impression of stereoscopic relief is not lost even with an unbalance as bad as 50 per cent.) The first thought in connection with measuring the milliamperage supplied to the tubes is, of course, to provide two separate milliammeters—one for each tube. This would require reading at high potential two milliammeters situated at some safe distance from the operator. Fortunately, the author has found a much happier solution for this problem, which permits both the measuring instruments to be grounded. The high potential transformer supplying the X-ray tubes is provided with a grounded middle point at which two leads are brought out permitting, in the ordinary fluoroscope, the insertion of a D.C. milliammeter in series with the secondary at this point. For stereofluoroscopy, *two* milliammeters, one for D.C., the other for A.C., current, are placed in series with each other and with the transformer secondary at this grounded midpoint (Fig. 8). The Jewel A.C. milliammeter, with scale from zero to 12.5 ma., serves well for the A.C. milliammeter. This instrument reads the *total* current supplied to the *two sources* of X-rays, since its deflection is indifferent to the direction of flow of current through

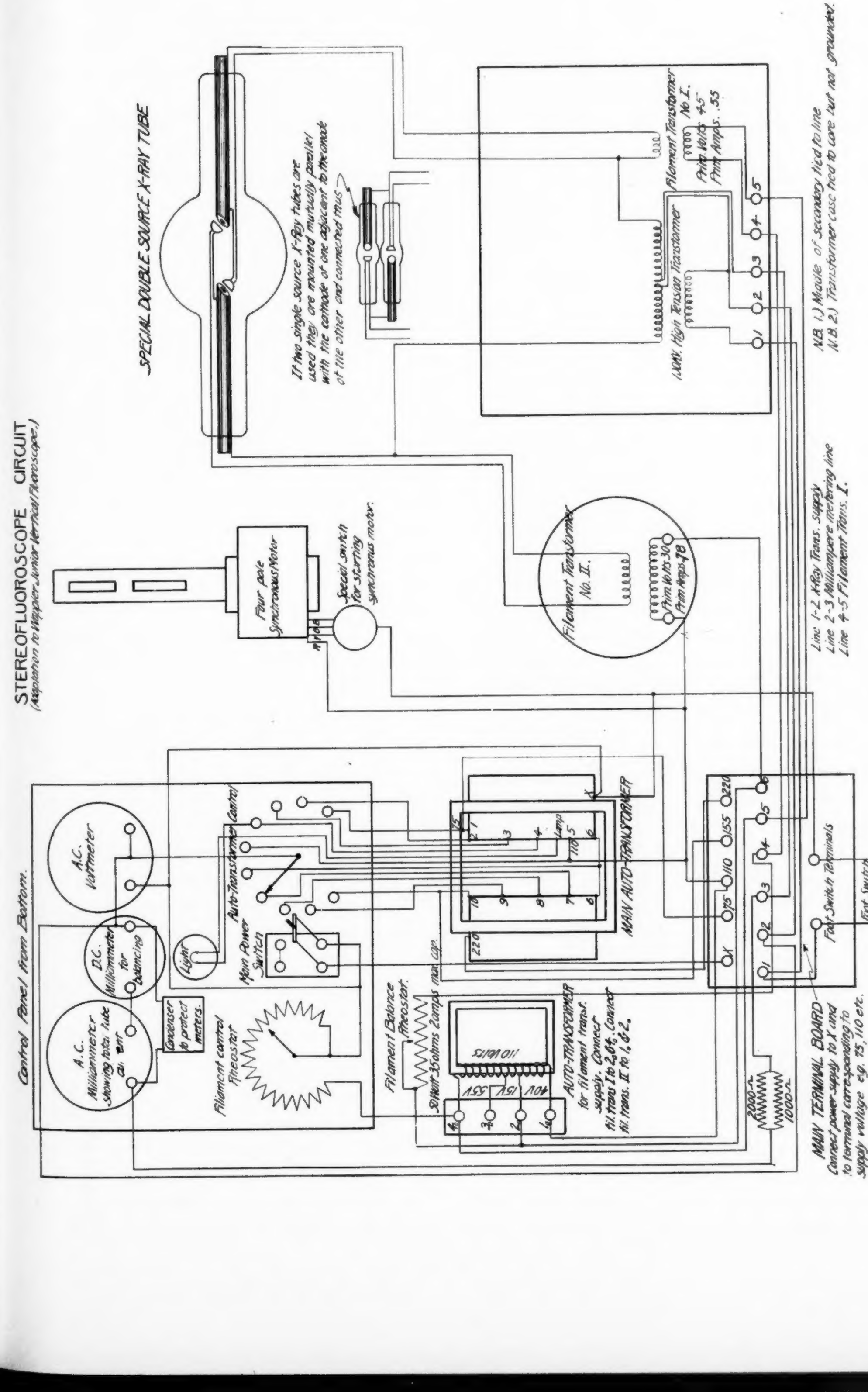



Fig. 14. Wiring diagram of vertical stereofluoroscope constructed for Dr. Opie and now in use at the Henry Phipps Institute, Philadelphia.

it. Its scale can readily be calibrated to read in terms of *average,* rather than root-mean-square current. The D.C. milliammeter should preferably be of the type with zero in the middle of the scale, permitting the indication of current in either direction. As it serves *merely to indicate the condition of balance* of the load between the two sources, it need not be a very accurate instrument. The tubes are balanced when this meter gives a zero deflection.

The advantages of this simple and effective metering scheme are:

1. The instruments are all at ground potential and can be located on the control panel.

2. The solution is a simple and cheap one. When an ordinary fluoroscope is to be remodelled for stereofluoroscopy, the D.C. milliammeter already on the control board can frequently be readily adapted to serve as the balancing meter.

3. While adjusting the milliampere load applied to the two sources with the single filament control rheostat, it is far better to read only *one* meter than to be obliged to watch two meters simultaneously. Similarly, it is much better to have only one meter to watch while balancing the load between the two sources with the filament balancing rheostat. With this system of controls and meters, the two operations of loading and balancing become separate, distinct, and independent operations—the most natural and convenient way to have them.

4. This solution is the one which adapts itself most easily to existing fluoroscopes, since these are always provided with a grounded center tap in the high potential transformer secondary circuit.

A complete wiring diagram of the stereofluoroscope built for Dr. Opie is shown in Figure 14.

*The Measuring Calipers.*—These can readily be seen in the two photographs, Figures 11 and 12. In the machine built for Dr. Opie, they consist of two slim, steel rods, bluntly pointed on both ends. At one end of each rod the point is bent into a hook. Either the straight or hooked points can be used to suit the convenience of the particular case. These rods hang from another slightly heavier steel rod permanently projecting from the top edge of the fluorescent screen. They are attached to this rod by universal joints which permit them to swivel and slide in a great variety of ways. They are provided with clamping screws to hold them in position, once they have been adjusted.

The points of the calipers can be placed in apparent contact with any two points in the stereofluoroscopic image. The accuracy and speed with which this can be done are surprising at first until one remembers that long habit in reaching for objects has endowed human beings with a highly perfected co-ordination between the stereoscopic sense and the muscles of the arm. The sense of touch plays no necessary rôle in this co-ordination, once it has been developed. On sharply defined outlines, it is safe to say that an error of less than a millimeter, or at most two, is to be expected in the observer's ability to place the caliper in apparent contact. Sharp outlines are, of course, essential to accurate localization.

In setting the two calipers preliminary to measuring a distance between them, obviously no motion of the observer's eyes must be permitted. Lateral motion is prevented by the nose piece on the eye shutter mentioned above. With a little care, longitudinal motion is easy to avoid, as sufficient friction is provided in the joints of the screen and shutter mounting to prevent them from moving except under decided pressure from the hand of the operator.

It is an easy matter to provide more than one pair of calipers so that the relative positions of a number of points in the object can be determined and measured at once. The facility with which measurements can be made of internal distances and positions

is one of the most attractive and striking features of the stereofluoroscope.

### CONCLUSION

The author wishes to make it clear that his contributions to the art of stereofluoroscopy, as described in this paper and for which he has applied for United States patents, constitute a sincere effort to devise a practical working instrument. These contributions consist of designs and improvements worked out through the construction and study of actual working models. The author is convinced that the solution of the problem has been delayed far too long by failure to approach it from this point of view. While he wishes to make no specific accusations, the fact that so many "paper" patents have been granted, without a single instrument appearing on the market to date, suggests that many patentees have been more interested in the possible obstructive value of their patent claims than in contributing constructively to the art. It is an unfortunate fact that many useful inventions are not available to the public because of the existence of obstructive patent claims held by patentees who have never spent a day in practical experimentation and development of their ideas.

In the present instance, however, the prospect seems good that arrangements can be concluded with a manufacturer to undertake, in the near future, the construction and marketing of the stereofluoroscope, to the mutual benefit of the inventor, the manufacturer, and the general public.

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*Survey Finds 10 per Cent of Cancer Patients Alive after Five Years.*—A survey of 1,802 cancer patients treated in seven Philadelphia hospitals in 1923 found slightly more than one-tenth of the group alive six years later. If the patient is alive and well five years after treatment for cancer, the treatment is considered successful by cancer specialists. Results of the Philadelphia survey were made public by Dr. Arthur H. Estabrook, of the American Society for the Control of Cancer. He was able to secure information about approximately nine-tenths of the cases treated in seven general hospitals.

His survey showed the following additional facts: *(A)* Nearly one-fifth of all patients admitted to the hospitals died in the hospital within a few months after treatment. *(B)* Of the 1,802 patients treated, 191 were alive six years later. Of these, in turn, 170 were in good condition, while 21 were in poor condition. *(C)* The group of patients suffering from skin cancer showed the highest proportion alive at the end of five years. The bone cancer group showed the next highest proportion of five-year survivors, and the other types of cancer showed the following order: cancer of the mouth, cancer of the breast, and cancer of the uterus. *(D)* Three-fourths of the entire group were known to be dead six years after treatment. A little over half of the total group, 957, died of cancer within one year following treatment. *(E)* Nearly one-half of the group delayed one year before seeking treatment. Only a small number (3.5 per cent of the total) went for treatment within one month after noticing that something was wrong. *(F)* "The period of delay, without consideration of other factors in the life history of the cancer, seems to have little correlation with the end-result of treatment," Dr. Estabrook found. *(G)* Nearly a third of those alive delayed more than one year before receiving treatment. About one-fifth of those who died received the first treatment within three months of first noticing the condition. More than a third of those who died received treatment within six months following the first symptoms. *(H)* Treatment by X-ray or radium was used in 810 cases. Radiation combined with surgery was used in 653 cases, and surgery alone was used in 336 cases. *(I)* Conclusions could not be drawn as to the effectiveness of the methods of treatment, Dr. Estabrook pointed out, because of insufficient data.—*Science Service.*

# MEDICO-LEGAL CONSIDERATIONS OF X-RAYS[1]

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ANN ARBOR, MICHIGAN

THE connection between law and the practice of roentgenology is of general interest. In all but a few States the practice of roentgenology is considered as the practice of medicine and is governed by the same legal statutes and court opinions which hold good for other practitioners. Legal opinions vary somewhat in different States, and in State and federal courts, but the general legal opinion is about the same all over the country.

A medical practitioner in general is described and understood as being one who is lawfully engaged in the practice of medicine or surgery and who holds himself out as being able to diagnose, treat, operate upon, or prescribe for any human disease, pain, injury, deformity, or physical condition. In general he does not belong to any particular school. Some States stipulate exceptions to the methods and means of treatment to be used.

Internists, otologists, roentgenologists, and other specialized branches are defined as devoting special study to their respective branches in medicine. In the eyes of the law each is bound to the common rule that he be required to bestow such reasonable and ordinary care, skill, and diligence as physicians and surgeons in the same neighborhood, in the same general line of practice, ordinarily have and exercise in like cases (Czajka *vs.* Sandowski, Mich., 219 N.W. 660). The law, however, goes one step further and says that he must keep abreast of the times, and, having stipulated this compulsory progress, it goes on to say that he shall not go beyond the accepted methods of modern practice in seeking a cure, unless, as handed down by a superior court, "he is prepared to take the risk of establishing by his success the propriety and safety of his experiment."

Whenever any hazard exists, one can always find some form of insurance to cover it. Insurance exists which is protection for the malpractice claims against the general practitioner and specialist, but the higher rate for those engaged in X-ray work, and especially in treatment, is in itself evidence that this method of diagnosis and treatment embodies hazards more severe than in any other branch of medical science.

The risks encountered by physicians owning and operating X-ray machines cover a wide scope and may be divided into two classes—personal and legal. Those in the personal class have to do directly with the patient, such as overexposure, insufficient protection, injuries resulting from mechanical defects of the machine, incomplete or inaccurate records, and after-care of the patient. The legal hazards are more or less predetermined by statutory laws or decisions of the courts; if the physician fails to meet the requirements as already set forth, then he may, according to the law, be held liable.

In malpractice cases, a bad result does not in itself indicate that there has been negligence, and it has been pointed out that the rule of *res ipsa loquitor* (the thing speaks for itself) should not apply. The physician is not an insurer and cannot be held liable for a bad result unless proof of negligence is produced [Edwards *vs.* Uland (Ind. App.) 131 N.E.R. 240]. The burden of proof rests with the accuser, and whether or not negligence did exist is a question for the jury to decide. The Supreme Court of Minnesota has said [Sawyer *vs.* Berthold, 116 Minn. 441, 134 N.W.R. 120 (1912)],

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

"It is undoubtedly correct that negligence of a physician and surgeon cannot be inferred from a poor result alone. There must be evidence from expert witnesses to show improper and unskillful treatment in order to sustain a charge of malpractice." Unusual sensitivity or idiosyncrasy of the skin of certain individuals to X-rays has been recognized by the courts in a case involving diagnostic measures rather than the prolonged exposure necessary for therapy [Antowill *vs.* Friedman (1921) 197 App. Div. 230, 188 N.Y.S. 777]. It is undoubtedly true that such a condition does exist and cannot, by any known means, be detected beforehand. In addition to such an antecedent condition as an idiosyncrasy, contributory negligence on the part of the patient may lead to an accusation of negligence on the part of the physician.

Liability growing out of diagnostic use of X-rays is now rare and should be unknown with the present-day equipment of high milliamperage and super-speed intensifying screens. Most of the claims arise from treatment. Of these, in New York State last year 77 per cent were against men recognized as being well qualified to administer proper care. The remaining cases were against men who were doing some X-ray work along with their other practice. The fact that technicians have been allowed to administer treatments without close supervision has been the basis for many claims, and the courts hold that the physician or hospital is responsible for the acts of assistants. In the same manner, a company or corporation employing a physician to do its X-ray work is responsible, but only in the question of whether or not, when employing him, it exercised due care in ascertaining his qualifications and ability. Men doing work for an institution devoted entirely to charitable work are not exempt from liability in case of a bad result or injury to a patient (3 R.C.L. 948, Sec. 12).

The general practitioner or surgeon may indirectly be involved in claims based upon X-ray examinations in that he did not use the roentgen ray as a clinical facility in order to establish a correct diagnosis or the progress of a case. Numerous references may be found citing such cases in which judgment has been awarded the plaintiff. Proof of negligence was established in that the evidence was sufficient to show that the physician had failed to exercise that reasonable care and skill which the law requires of his profession. The Committee of Medical Defense of the Iowa State Medical Society says, "A physician's failure to avail himself of roentgen rays is not in itself evidence of neglect, but a physician armed with a roentgenogram can defend himself much better than one who is required to rely on certain evidence."

It is, therefore, inferred that the general practitioner who keeps abreast of the times need not acknowledge want of skill, and is held responsible only to the standards of the practice of medicine in his neighborhood. The urban and rural rule is not applicable to the roentgenologist. The Supreme Court of Virginia in affirming a judgment [Hunter *vs.* Burroughs (Va.) 96 S.E.R. 360] says, "It should be borne in mind that the case involved two standards of professional skill and care by which the evidence as to the competency and conduct of the defendant was to be measured; one standard having reference to the technic or mechanical operation of the roentgen apparatus, and the other standard having reference to the possession and use of the professional skill and care incumbent upon the defendant with respect to diagnosis and treatment of the disease of the plaintiff in matters other than the mere mechanical operation of the apparatus." The double requirement mentioned in this decision has a great bearing on radiology. Since the physicists are responsible for the latest developments in the accurate measurement of correct dosage, it may be

expected that the radiologist be not only a physician but a mechanic and a physicist.

The X-ray film is becoming more frequently a part of court room procedure than ever before. X-rays were first used as evidence shortly after their discovery (Smith *vs.* Grant 29, Chicago Legal News 145, Dec. 3, 1896), and now, in practically every injury case, roentgenograms are introduced as evidence. In the absence of conclusive proof, courts may even require submission to the taking of roentgenograms, although some courts have ruled that information obtained from examination of the films of individuals be considered as a confidential communication, not to be divulged unless a waiver has been obtained from the patient [Stapleton *vs.* C., B. & Q. R. R. (Neb.) 162, N.W.R. 644].

In reversing a decision of the lower court, the Supreme Court of Illinois established a rule which has been very important. It is that, although X-ray films are regarded more or less as common photographs [Eckles *vs.* Boylan (1907) 136 Ill. App. 258], they cannot be admitted as evidence until proper proof of their correctness and accuracy is produced. In the case of Ligon *vs.* Allen (1914), 157 Ky. 101, 162 S.W. 536, 51 L.R.A. (N.S.), 842, it was said, "If no witness has attached his credit to the photographs then it would not come in at all any more than an anonymous letter should be received as testimony."

The roentgenologist is frequently called into court to give expert testimony upon films, but it is also a common practice to have the films identified and then to question the attending physician regarding their interpretation, irrespective of whether or not he has any special knowledge of the significance of the shadows. Several decisions have been handed down in which it was made unmistakably clear that the court errs in allowing laymen, technicians, and others to read evidence which is not there, into films, which facts cannot be discerned by the ordinary jury, as if the so-called "picture" were a photograph. As stated before, the decisions in some States have set up a double standard, while in others, notably in the case of Sweeny *vs.* Erving (1910) 35 App. D.C. 57, 43 L.R.A. (N.S.) 734, 228 U.S. 233, 35 S.Ct. 416, 571 ed. 815, the court seems to assume that anyone licensed to practise the healing arts should have a full knowledge of all branches of medicine and surgery and quotes, "The use of X-ray in diagnosis and treatment of disease is recognized and practised by the medical profession; such being the case, we see no reason why a different rule should apply to practitioners in this line than is applied to other practitioners."

The basic rules for introduction of a photograph as evidence have been transferred to the X-ray film, but at no time is the diagnostic quality of the film ever tested. The film may be explained by experts and may be taken to the jury room just as papers read as evidence, but whether or not it portrays all that could be shown by this method is never questioned. The late Chief Justice Taft said, "When a case depends on a highly specialized art with respect to which the laymen can have no knowledge at all, the courts and jury must depend on expert evidence—there is no other guide." To bear out this opinion, cases are on record in which it is shown by the Appellate Court that the testimony of unqualified witnesses should not have been allowed.

Numerous incidents of accidental electrocution or injury by coming in contact with high tension wires have occurred. We have been unable to find a legal opinion in any of the cases of death in this manner, but those involving injury by coming in contact with high tension seem to show that the physician is bound by implied contract for liability to the patient, but not to those accompanying the patient. Any injury to persons accompanying the patients—parents, nurses, or physicians—is covered only by a

general liability insurance and is not included in the malpractice policy.

The ownership of the film has not as yet been settled in the higher courts, but a decision has been rendered which is often referred to in which it is stated, "There was undisputable evidence that the X-rays taken in this hospital, as these were, are considered hospital property." In a recent decision in the Genesee County, Michigan, Circuit Court in the case of Hurley Hospital *vs.* Gage, the court ruled in favor of the hospital. In giving judgment, the court pointed out that the hospital sold and patients paid for, not the material that went into roentgenograms, but knowledge and experience. This case had had a justice court opinion in favor of the plaintiff and, because of the principle involved, was carried to the Circuit Court. No supreme court decision has as yet been given. It has been definitely established that photographic films are the property of the photographer, but the disposition of prints rests with the "sittee" and exhibition of either prints or negatives invades personal privacy [Corliss *et al. vs.* Walker (1894) 64 Fed. 280, 31 L.R.A. 283]. The roentgenologist acts as a consultant and films given out indiscriminately, as some are to patients and relatives who "shop" for opinions, are potentially dangerous. An indiscreet remark by some fellow-practitioner may lead to the idea that sufficient damage has been done to warrant legal action.

The greatest risk of the roentgenologist is that X-rays are inherently a dangerous physical agent and that the laity are aware that burns and disfigurement may follow administration of X-rays for therapeutic purposes. Errors in diagnosis are errors in judgment and are not actionable, but errors of omission, such as imperfect records, incorrect administration of the treatment, and so forth, are questionable and the final disposition of the case rests with the jury. It is doubtful if a written agreement not to hold the physician liable is legally binding, although the practice of obtaining such agreements may tend to dissuade many persons from pushing their claims.

Insurance rates, which are in direct proportion to the risk taken by the companies, vary in different localities. Concerted efforts on the part of the roentgenologists and the insurance companies should minimize the risks, and these efforts should tend to lessen the hazards encountered in this field. The medico-legal aspect of roentgenology brings out many factors which are attractive to the malpractice lawyer and his client. To discourage this lucrative practice, which in some States has become a menace, it is apparent that it is well worth while to become acquainted with the facts in order that this knowledge may lead to a co-operation which will reduce the risk of each individual and prevent the unpleasant situation of even a threatened suit.

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## DISCUSSION

Dr. I. S. Trostler (Chicago, Ill.): Professional warnings along medico-legal lines, such as this, should receive more attention than they apparently do.

When Dr. Donaldson discusses malpractice insurance, he comes close to our hearts; or perhaps I had better say close to our purses. I am glad to note he recognizes that the

principal reason why we, as radiologists, are required to pay a higher premium rate for that insurance than do other medical practitioners is because radiologists present greater hazards, greater risks, than do other practitioners.

Most of you are familiar with the investigation of the malpractice insurance problem that I conducted for this Society several years ago and with the results of that investigation. I am still at that work and hope to be able, at some not long distant date, to show the insurance companies that men who have had long experience and own complete equipment are better risks than are beginners with simple apparatus and incomplete equipment.

It is quite true, as our essayist says, that "the law allows for error." The law does not expect us to be infallible and we are not held responsible for honest errors of judgment if our methods are in conformity with, and along the lines followed in, the community in which we live and in similar localities. At the same time, we must show that we are capable of formulating and using good judgment, that we have the usual and ordinary skill, and that we exercise the usual amount of care in applying that skill.

Employers' liability for the acts of their employees comes from either the relation of principal and agent or from the relation of employer and servant. In the former, the well known axiom, "The principal is responsible for the acts of his agent," applies, while in the latter the legal doctrine of *respondeat superior* (the master is responsible) is made to apply.

However, when a physician is the employee, the doctrine of *respondeat superior* is generally held *not* to apply because in the performance of our duties as physicians we are *not subject to rules or instructions* as to what we should or should not do, or how or where we should do things, as compared to other employees, but we must rely upon our own judgment.

Therefore, our lay employers should not be, and as a rule are not, held responsible in the event that we err, neglect, or fail to exercise the necessary amount of skill and care.

On the other hand, we, as physicians, are nearly always held legally responsible for the acts of our nursing and technical assistants and non-medical employees if they are acting as our agents, as well as if they are acting only as our employees.

Right here I want to interject a thought for your consideration. I have about come to the conclusion that we should try to enforce the doctrine that general practitioners of medicine can and should be held legally liable for the acts of lay technicians who are conducting pathologic and roentgenologic laboratories to whom they (the medical practitioners) refer their patients. I propose to bring this up in Chicago very soon and, if we can enact this legislation, it should have a most salutary effect upon that much-to-be-deprecated practice.

Relative to the ownership of roentgenograms, I have repeatedly urged attorneys to bring action to force roentgenologists to yield possession. However, up to this time, none of them would do so after hearing or reading the arguments in favor of the claims that I made in a paper read before this Society in Chicago some fourteen years ago.[1]

Dr. Donaldson mentioned the Hurley Hospital affair in Genesee County, Michigan, which is really the first instance of a court of record making a decision that the roentgenogram belongs to the hospital. We can take it from that decision that the film belongs to the roentgenologist or the laboratory or the institution making it, unless the contract is for roentgenograms and not for roentgenographic examinations.

This is a distinct victory of which radiology can well be proud. I hope that the plaintiffs will carry it to the Supreme Court of Michigan, although I very much doubt that they will do so because not a very large amount of money is involved. If they do, I am sure we will win there.

While this subject still comes up sporadically for argument, I am of the opinion that we can safely consider settled the question of the ownership of the roentgenogram. The action

[1] I. S. Trostler: Jour. Roentgenol., 1918, I, 418-425.

of this Society of Dec. 16, 1920 (page 102, 1931 roster), was probably the most important element in that settlement.

I am glad that Dr. Donaldson so strongly stresses the importance of keeping perfect and complete records. His former chief, our late lamented Dr. Preston M. Hickey, used to stress that. I had the privilege of conferring with him and being advised by him regarding several presentations relative to this particular subject.

As I stated, this is an important subject and it should receive careful and heedful consideration.

Dr. J. H. Carpenter (Chicago, Ill.): I was very much pleased to have the essayist bring out the point that the technical laboratory is being run by laymen and the point of the use of X-rays as a practice of medicine. I think these are points upon which we have been very weak in the past. Many laboratories are operating that could be easily suppressed if some concerted action were taken. The fact that the physician using the X-rays has to pay malpractice insurance far in excess of that of other lines in the practice of medicine seems to me proof of the necessity of greater precaution in the exercise of the use of the X-rays than there is at present.

The nurse is used to seeing the surgeon operate, but we would not think of letting her perform a surgical operation. The insurance companies, by their change in the rates of the surgeon and the roentgenologist, have decided that the use of X-rays is far more dangerous than the operative procedure. It seems to me that, when the dye is administered in the examination of the gall bladder, there can be no question but that a drug is being administered to that patient. Yet lay laboratories are doing that day in and day out and nobody is taking any steps to stop it.

Dr. A. David Willmoth (Louisville, Ky.): This is an important question in my State. For a number of years we have had an efficient State Board of Health, and we no longer have lay laboratories in Kentucky—we have just closed three.

In Kentucky we have gone a step further than in any other State in the Union. We now have an examining board for roentgen technicians, and no technician, male or female, can operate a machine there without passing the examination of this board, which is part of the medical board. As this board has but recently been organized, all operators who had not practised two years prior to January, 1930, will take the board examination. They have also to present certain requirements as to schooling and other points.

Why do the insurance companies charge us more? It is because we rely on technicians to operate machines, and since the courts have held that we are responsible, the insurance companies hold us responsible and increase our rate. That is the reason why you pay more—because of the untrained technicians who are operating machines. The insurance companies have taken cognizance of that fact and are charging for the additional risk. After all, is it not right that technicians should be trained? The Doctor brought up a very important question just now. The patient does not know. He submits to whoever is operating the machine, trained or untrained. Whether the operator is familiar with high tension energy or not, the patient has to take the chances.

It is likewise true with treatments. I could give you many instances in which the crudest, almost the lowest, form of intelligence was used to operate machines and give treatments with the result that the patients were burned. No wonder the insurance companies retaliate by increasing the rates.

The question seems to be raised in Kentucky that we must have better technicians, and we are going to have them. We are going to do just what the medical profession, the dental, pharmacal, and nursing professions did—exact and demand—and we intend to have licensed technicians for the operation of every machine in the State of Kentucky.

Dr. L. S. Goin (Los Angeles, Calif.): This is so important a subject that I marveled to hear some gentlemen say that this, being a medico-legal paper, must not necessarily be heard.

You are all in the gravest professional and financial danger from day to day. Malpractice suits arising out of alleged X-ray burns are becoming more common because of certain rulings that the courts have made. I think you all know what is expected of a physician in order that he may defend himself against a malpractice suit—that he shall use the ordinary care and skill which is common to the men practising his profession in his vicinity.

This is a general rule of law, but the courts have now decided that there are two kinds of persons practising medicine: the general practitioner and the specialist. Any man who limits, or claims to limit, his practice to a limited branch of medicine becomes automatically a specialist, whether he wishes to be or not. As a specialist, he is required to observe the same degree of care and skill that is required of all other specialists. That is to say, a man practising in a town of ten or twelve thousand people is supposed, in conducting an X-ray laboratory, to have the same degree of skill and to use the same degree of care as a man practising in Chicago or New York City.

Another very serious decision recently reached by the California Supreme Court (and, Dr. Donaldson tells me, by two or three other supreme courts) is that an X-ray burn is itself evidence of negligence on the part of persons operating the X-ray machine.

There is at law what is known as the "burden of proof," which is to say that if I sue one of you and claim that you defrauded me, I have to prove that you did so. You do not have to prove that you did not. If I am arrested and brought to trial for burglary, the State is obliged to prove that I am guilty. In the matter of X-ray burns, the burden of proof shifts, and it becomes encumbent upon a man to prove that he did exercise due care in operating the X-ray machine.

In view of the fact that this paper is a matter of such vital importance to every one of us, we should all take it very much to heart.

Dr. Donaldson (closing): In regard to insurance, the rates are higher for the roentgenologist who devotes his full time to the work. In fact, in some States they are three or four times as high as those for the general practitioner.

The general practitioner who owns an X-ray machine may operate it at his general practitioner insurance rates so long as referred X-ray work does not exceed 10 per cent of his practice. The rates are based entirely on the physician's own statement as to how much X-ray work he is doing.

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*Finds Relation between Fat Content of Tumor and Severity.*—The more severe, malignant tumors of high killing power, such as cancer, contain a much higher percentage of fatty substances than the less malignant tumors, Dr. Morio Yasuda, of Tokyo Imperial University, and Dr. W. R. Bloor, of the University of Rochester School of Medicine and Dentistry, have reported to the American Society for Clinical Investigation. Their report, published in the *Journal of Clinical Investigation,* is based on chemical analyses of various kinds of human and mouse tumors made at the University of Rochester.

The tumors analyzed were divided into three groups according to degree of malignancy, as far as this could be estimated. In the first group of less malignant tumors the various fatty substances, such as phospholipoids, cholesterol and neutral fat, were present in low percentages. These tumors included the types known as fibrosarcoma, neurofibroma, fibromyoma of the uterus, and colloid adenoma of the thyroid gland.

The two malignant groups, containing a high percentage of fats, included human carcinomas, or cancers, of stomach, pancreas, breast, uterus, and colon, and mouse carcinomas. Some of the tissues upon which the human tumors were growing, such as uterus muscle and colon tissue, were also analyzed, and found to have a much lower percentage of fatty substances than the tumors or cancers.—*Science Service.*

# ANOTHER OWNERSHIP DECISION FROM MICHIGAN

By I. S. TROSTLER, M.D., F.A.C.R., F.A.C.P., CHICAGO

IT appears that Michigan is out to make records and establish legal precedents on the ownership of roentgenograms. Another case, in addition to the former favorable decision cited by Dr. S. W. Donaldson,[1] which stated, "There was indubitable evidence that the X-rays taken in this hospital, as they were, are considered hospital property," has been recently reported.

In the former case the decision was the end-result of a suit for a hospital bill against a patient, but in the case to be related (decided April 4, 1932) a woman who was planning to start a malpractice suit against her physician, brought action against her physician and the radiologist who made the films, to replevin the films.

In the hearing of the case before the Circuit Court of Ingham County, Michigan, the presiding judge instructed the jury to bring in a verdict in favor of the defendants, as follows:

"Gentlemen of the jury, this is a rather interesting case in some of its aspects. But as I view the situation it resolves itself into a question of law.

"Now it appears that these X-ray films were taken by Dr. Pinkham; he had them in his possession at the time that this action was instituted. There is, however, no showing in the case that these X-ray films at the time of the institution of the suit or at the present time had or have any intrinsic value whatever. Replevin lies to recover property that has value. It will not lie to recover something that has no value, and, as I say, there is no proof of value concerning these X-ray pictures or films.

"And then we come to the question, passing by this matter of failure to prove value. When X-ray films or pictures are taken by a physician, is there any implied undertaking on the part of the physician taking such pictures that they will be turned over to the patient? The undisputed evidence in this case is to the effect that it is customary that such films be retained by the physician who has taken them,—retained by him as a part of his record concerning the case; retained, I suppose, on the same basis and on the same theory that he retains his temperature chart that he has made or other record concerning the diagnosis or treatment of a case. That testimony stands undisputed in this record. I think it must be conceded that it establishes an uncontradicted custom touching and concerning the subject matter of this case. And that as a matter of law it must be said that where X-ray pictures are taken by a physician under the circumstances such as they were by Dr. Pinkham in this case, there is no implied undertaking to turn these films over to the patient.

*"It becomes the duty of the court, therefore, to direct you to return a verdict of not guilty as to both defendants, and the clerk will receive the verdict."*

The verdict was brought in according to the judge's instructions and we are informed that "indirect information indicates that the case will not be carried up to the Supreme Court."

In the former case from Michigan, the decision gave possession to a hospital, while this decision gives a physician the title to the roentgenograms.

It is so seldom that the medical profession gets "the breaks" in a matter of this kind that we cannot help feeling a bit elated and jubilant when we get two successive decisions like the foregoing.

[1]Medico-legal Considerations of X-rays, RADIOLOGY, this issue, p. 388.

# EDITORIAL

LEON J. MENVILLE, M.D. . . . *Editor*
BUNDY ALLEN, M.D. . . *Associate Editor*



## RELATION OF THE PRESS TO THE DEVELOPMENT OF RADIOLOGY[1]

Sometimes I think that you men of science don't realize quite how difficult it is to tell your story to other people.

In a city where I visited a short time ago, writing news about a scientific meeting, one of my stories went to one of the local Associated Press papers. They had a rule that they used nothing locally from the Associated Press; my story had to be re-written. One of the older editors was assigned to re-write it and he grumbled about it and said, "I can't do that. I'd just as soon try to re-write the Word of Christ."

When you stop to think about the remark, it is not a compliment. A newspaperman can re-write anything, including the Bible, if he has ever had a chance to read a little bit about it and knows the terminology!

About a year ago Gilbert N. Lewis, head of the Department of Chemistry at the University of California and one of the leading scientists in the world, presented a new hypothesis to the National Academy of Sciences. Dr. Lewis said, "If you take two invisible and intangible particles and compare them and find out the things which they are not, by that very method you can scientifically determine a good many of the otherwise unknowable things about what they are."

Well, I was there. I wrote a story and I took it to Dr. Lewis and asked him to correct the mistakes. He read the story and then he said, "This is all O.K. except the sunset."

"But," I said, "Dr. Lewis, I didn't mention any sunsets."

"Oh, yes, you did," he said. "All this first part where you tell about the possible great benefits to humanity some day of this hypothesis of mine, if it proves true and should happen to work some time, all that is sunset painting and it is not fair to the scientist."

Well, I took the story back and, frankly, I must admit I spent a whole day getting a new lead, a new first part for the story. Finally I wrote it, took it back to Dr. Lewis, he read it and said, "Now this is O.K."

I wish to say to you that it was still a sunset!

Newspapers are always sunset-painters and always will be and sunset-painting rouses the interest of the ordinary man. All of us want to know what the end of the trail is going to be. That is the reason for writing sunsets. That is the reason why everything presented to the average man must be in the sunset form.

I propose to try to tell you how you can make use of some of this strange sunset-painting to build up the things you are interested in in radiology.

At Penn State University Dr. D. E. Haley has been studying the effects of tobacco of a very high nicotine content (6 per cent) upon chickens, and he finds that it is a quick cure for a certain type of round worm which is costing several million dol-

[1]Presented before the Radiological Society of North America at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

lars to the American poultry industry. He finds also that this high nicotine content is a good thing for the little chicks. He published that in a scientific paper—in two or three scientific papers—and just exactly nothing happened.

Then the Associated Press came along one day and it wrote a sunset which started off by saying that at Penn State University they are raising bigger and better baby chicks by feeding them lots of tobacco.

I think that the first impression of the scientific men of my acquaintance would be, "That's bad. You shouldn't ever tell a scientific story that way."

But in the files at Penn State are letters, scores of letters, which came from all around the world after this one sunset-picture appeared in the newspaper, and from whom do you suppose the letters came? They came, first of all, from scientists and they came from poultry men; they came from people who wanted information. So many of the people in the poultry business wrote letters that it looks as if this discovery is going to wipe out one kind of loss for the American poultry industry.

Near Los Angeles there is a place called Rancho la Bria. It is an asphalt ooze, filled with bones—they just whiten the place. It has been known for two hundred years or more, ever since the days of the Spaniards, and for the first several score years people thought they were just bones and tossed them aside.

Then one day in the last century a man from Boston went to Los Angeles, looked at these bones, found there saber-toothed tigers, lions bigger than anything that exists to-day, prehistoric bones of all sorts—in short, a record pretty well chronicled of twenty million years, the richest single page of paleontological records in the world.

He went back to Boston and published it in a scientific paper and about twenty-five years afterward Rancho la Bria was discovered by some other scientists. Two weeks ago a man who is the head of the largest, probably the greatest, scientific institution in the United States, in telling me that story about the two discoveries of Rancho la Bria, said that nobody in the scientific world ever heard of that first report, but that if the information had been published in any newspaper by the Boston man we wouldn't have had to wait twenty-five years to re-discover Rancho la Bria.

This man went on to tell me an incident about the Mendelian laws of inheritance. You know them; I don't need to describe them to you. You recall that Mendel made his discoveries, wrote them, and that his manuscript was lost to everybody, and that the discovery of Mendel's manuscript was one of the sensational events in the scientific world.

Well, the incident is this: One of the great geneticists of the United States says that before the re-discovery of Mendel's paper he had it lying on his desk for five years, and he never had time to read it. He didn't read it until somebody else re-discovered it.

The point of all these anecdotes is to try to convince you, after you have had time to think it over, that one of the reasons for meeting newspapermen half-way and giving news of science to newspapers is that scientists shall know what is going on in science.

At Purdue University last October [1931] I saw a unique steam boiler. It produced steam at 3,500 pounds pressure to the square inch. At the end of the World War steam boilers were averaging 300 pounds to the square inch, and now a half-dozen plants in the United States go to 1,200 pounds steam pressure to the square inch. In ten years, since the War, we have jumped to 3,500 pounds.

"Well," I said, "what has happened? How could you make that rapid progress in such a short time?"

"Oh," the answer was, "partly because we have the materials. We have new alloys, new instruments."

The principal thing which the press does to help radiology and all other science is to help build the materials. We can spread a little information, perhaps, about new instruments, but, more important than that, we inform the public about what is going on—and the public is half of your materials and a very important half.

Also, from the public, in one way or another, comes a large part of the support which makes scientific progress possible.

Last July [1931] in the Westinghouse Research Laboratories at East Pittsburgh one Saturday noon Dr. N. Rashevsky, a mathematician, closed up his shop. On one side of the room he had eighteen frogs in a glass dish,—nice, healthy frogs. On the other side there was a sick frog in a glass dish. That is why he separated them.

Saturday afternoon there was an explosion, an experimental explosion caused by the rending apart of some metals in a different part of that great scientific laboratory. Monday morning when Dr. Rashevsky came in, all of his healthy frogs were dead and the sick frog was still just as sick but he was alive.

Rashevsky investigated. He concluded that a super-sound wave, travelling near the wall where the healthy frogs were, had killed all eighteen of them. So the Westinghouse gave out the information that way and the newspapers carried the story that way. Within a week one of the officials of the company received a letter from a layman which read, "If you've got money to fool on frogs, why don't you spend it on dividends?"

I suppose that writer, that layman, never had heard about the German dye industry. The business men in Germany, so the story goes, gave some pure scientists twenty million gold marks and let them fiddle along for fifteen years without any results until finally they achieved a real result and, with it, a monopoly for a while of the world's dye industry.

An engineer of one of the large radio companies chose to make predictions about the future of radio, saying, "The day will come when you will have television by radio." He went into some detail. I don't know whether he failed to say how many years it would be before we had television by radio or whether the newspaperman who wrote it up inadvertently omitted the number of years, but it got into the newspapers without any time limit on it. Within three days, I think it was, the radio manufacturing companies received 35,000 cancellations for radio sets already ordered and 65,000 orders for the new television radio sets.

I am trying to convince you that the public is interested in science, that when you put it in the newspapers the public gets it—from the truck driver on up or on down, whichever point of view you may have. The time has come when science, for its own protection, must step out and try to take a little control of this thing.

For example, I blame the scientist far more than I do the cub reporter who made the following mistake not long ago in his newspaper in writing about a new scientific development. Said the boy, "A new synthetic resin has been developed which is more invisible than bakelite."

Not so long ago the College of Physicians and Surgeons at Columbia, Harvard Medical School, and Johns Hopkins received a bequest of six or seven million dollars, all in one lump sum, from a man in Boston. At one of those colleges the executives and professors got together and said, "Who is this man? We never heard of him. Where did he get all that money? What have we been overlooking? We didn't know anything like this was coming to us."

So they investigated and they found out

that one day a physician from P. & S. had been attending this man for some illness and the patient said, "Doctor, what is a good place to leave one's money?"

And the doctor said, "Oh, to a medical school."

"Well, Doctor, what are the three best medical schools in the United States?"

"Harvard, Johns Hopkins, and P. & S."

The men who do the thinking at this college concluded that that incident was the reason why perhaps medicine instead of some institution got the money and why P. & S. got its share.

The man who told me the story said, "There are angels all the time flopping all around, looking for places to deposit their canes, and you never can tell what kind of an incident will cause them to choose the place where they are going to leave their money."

About four hundred years before Christ, Alexandria had a good start in science with vivisection in biology, and Athens had an equally good start in agriculture, experimenting with plants. Then Rome came along and conquered the world and we settled down to quite a spell of rather coarse living without much science.

I make bold to state that had there been a few advertising men at that time with modern newspapers, and had they written some wonder stories about the marvels of Burbanking, perhaps the Dark Ages wouldn't have lasted quite so long.

But to-day, unless science becomes active in telling its stories there is danger of slipping back into some sort of a Dark Age so far as science is concerned!

Advertising is one of the biggest forces which has made the present civilization—whatever value you place on that civilization.

I cannot conceive of scientists letting advertising go by the board without making some use of it. I know that ethics prevent most of you who listen to me from advertising, but I say to you that it is dangerous not to find some method whereby science can make this modern instrument of service.

Dr. Ries, a geologist of Cornell University, was asked to write for the Associated Press a short story of just a few hundred words telling all about geology. He said, "I have been asked to write for the radio and I am told that, for the radio, I must write for twelve-year-old intelligences. If I write for the press, may I speak to the thirteen-year-old intelligences?"

We told him to go ahead and write in his own style; also, we asked twenty other scientists to write in their own styles about their own fields and we said to them, "You make your remarks as short as Lincoln's 'Gettysburg Speech.' "

Imagine describing radiology or any other science that way! But they did.

We sent those stories out six months ago. It took nearly a month to get them out, day after day. I watched the newspapers. The headlines were usually two columns, sometimes three, and I saw one seven-column streamer.

These stories were written by scientists in their own language and we didn't edit them and neither did the newspapers edit them.

The time has come when it is possible in a very practical way for scientists to meet the newspapers half-way and the idea that it could be done didn't come from me, a science editor; it came from one of our lay editors. And the fact that science is in the Associated Press does not come from science; it comes from the present General Manager of the Associated Press. When he was a younger man, one day he was watching a machine set up on a table, all by itself. It was an automatic printer. There was no wire connected with that machine. There were no human hands there. Nobody touched the table; there was nothing

under the table. The machine was typing a message just the same. It was the first test of sending automatic printing by wireless and to Cooper came the vision of what a great news story science would be.

A few years later he was at a conference with the head of the Western Union and the head of Stevens Institute in New Jersey, and they were talking over the possibilities of news being of service to science, especially for raising funds. The scientist of the party said, "Why, the public doesn't realize what science has done for it. Even sleeping is more pleasant nowadays because of the scientific research on bed springs."

And again to Cooper came that vision, and when he became General Manager he said, "Let's have a science department," and so, to make a long story short, we have the science department. We are trying to meet science half-way. Science is news. It is first-page news. I have a telegram saying that the *New York Times* printed a report on page one to-day which went out of here last night that you were going to meet to-day. First-page news! There isn't anything that you or I can do that will keep it out of the newspapers!

So I wish to suggest, to urge, that you take that fact, that condition, and make use of it by helping us, by meeting us, the newspapermen, half-way.

HOWARD W. BLAKESLEE,
*Associated Press Science Editor.*

## ANNOUNCEMENT

The American College of Physicians will meet in Montreal, February 6-10, 1933, with headquarters at the Windsor Hotel.

Dr. Francis M. Pottenger, of Monrovia, Calif., as President of the College, has charge of the program of General Sessions. Dr. Jonathan C. Meakins, Professor of Medicine and Director of the Department, McGill University Faculty of Medicine, is General Chairman of local arrangements and in charge of the program of Clinics. Mr. E. R. Loveland, Executive Secretary, 133-135 S. 36th Street, Philadelphia, Pa., is in charge of general business arrangements, and may be addressed concerning any feature of the forthcoming Session, including copies of the program.

## BOOK REVIEWS

DIE SCHLEIMHAUT DES VERDAUUNGSKANALS IM RÖNTGENBILD. EINE NORMALE UND PATHOLOGISCHE RÖNTGENANATOMIE DER INNENWAND DES VERDAUUNGSKANALS. By HENRI CHAOUL and ALBERT ADAM, with a Foreword by FERDINAND SAUERBRUCH. A volume of 229 pages and 219 illustrations. Published by Urban and Schwarzenberg, Berlin, 1931. Price, 25 reichmarks.

Recent years have witnessed many papers and several monographs concerning the roentgenologic demonstration of mucosal relief patterns of the gastro-intestinal tract. This monograph by Chaoul and Adam is particularly outstanding because of the comprehensive nature of the presentation, the practical and logical manner in which the subject is discussed, the conservative attitude maintained by the authors, and the frequent references in the text to the literature. The illustrations are excellent although many appear to be retouched.

The authors first consider the various methods of studying the mucosal relief and their application to the various parts of the gastro-intestinal tract. The Chaoul compression bulb and band, which has been widely used, is described in detail and a large percentage of the illustrations were made with its use, thus testifying to its efficiency and practicability.

The normal appearance of the mucosa is described in detail and the physiology of the gastro-intestinal tract as it relates to the mucosal pattern is also discussed. Many illustrations depicting this use of the relief technic in various portions of the stomach are shown. Permanency in the pattern of the normal gastric mucosa is emphasized.

The discussion of pathologic alterations in the gastric mucosa is particularly well presented and the accompanying illustrations emphasize the possibilities of this method. In considering the differential diagnosis, the authors present excellent roentgenograms showing the alteration in relief patterns produced by extrinsic and intrinsic disease. Changes due to the former are frequently misinterpreted by the inexperienced. In considering an abnormal mucosal pattern of the stomach the authors discuss the functional irregularities in the pattern which accompany gastric and duodenal ulcers. There are excellent examples of hypertrophy associated with duodenal, gastric, and gastrojejunal ulcers. In the consideration of atrophic changes the effects of pyloric obstruction, retained secretion, associated ulceration, and inflammatory conditions in the gall bladder, duodenum, and pancreas are described. The sections pertaining to gastric ulcer and gastric malignancy are illustrated by many roentgenograms which depict the value of this method in demonstrating the extent of the lesion.

In the part concerning the post-operative stomach will be found many examples of normal and abnormal anastomoses. Undoubtedly the relief technic offers much in the diagnosis of this perplexing group of conditions, and the authors' illustrations, particularly those relating to gastrojejunal ulcer, are most instructive.

In making relief roentgenograms of the colon the authors seem to prefer the compression technic, using small amounts of barium. Several cases in which the contrast method (air and barium) was used are shown, although the amount of air used is less than that preferred by recent authors.

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Anatomie des Lymphatiques de l'Homme (Anatomy of the Human Lymphatic System). By H. Rouvière, Professeur d'anatomie à la Faculté de Médecine de Paris; Membre de l'Académie de Médecine. Cloth, pp. 489, with 129 illustrations. Masson et Cie, Paris, 1932. Price, 150 francs.

The importance of the lymphatic system in normal and pathologic physiology cannot be over-emphasized because it is in closest physiologic relationship with all tissues and organs. Since it is through this system that infections spread, and extensions of malignant tumors take place, a fundamental knowledge of the lymphatics is necessary for the internist, the surgeon, and the radiologist that they may understand many of the various morbid processes with which they deal. In the combat of cancer both by surgical and radiologic methods, a precise knowledge of the lymphatic system of the particular organ in question is necessary so that the attack may be planned to best conserve the welfare of the patient. The great importance of the lymphatic system explains the wealth of literature on the subject.

The present work by Rouvière amplifies and supplements the previous anatomical works of Cruikshank, Mascagni, Poirier, Most, Teichmann, Sappey, Cuneo, and others, and summarizes the patient researches carried out by the author and his assistants over a period of seven years. By painstaking injections and dissections the descriptions of the lymphatics already published were checked and verified for each organ (save those of the central nervous system), so that the author's is the most complete and accurate of all the descriptions of the lymphatic system of man. The book cannot be abstracted. It consists in a complete and methodical description, region by region, of the anatomy of all the lymphatic nodes, the channels which drain into them and into which they empty, together with a discussion of all the variations from the normal.

The exposition both by the printed word and by the illustrations in the text is masterful. In each chapter the experience of the author is compared and contrasted with that of other workers in the same field. The volume is enriched by 129 beautiful illustrations, mostly by A. Moreaux, made under the supervision of the author, which clarify and supplement the text. At the end of the book there is a bibliography of 768 references. Because of the excellence of the subject matter this volume is of the greatest value to anatomists, pathologists, surgeons, and radiologists. To those teaching anatomy, particularly in its practical medical or surgical applications, the

book is of primary importance. In such a mine of accurate information one may find the explanation for obscure or paradoxical metastases of malignant tumors, and from the information obtained one may more scientifically plan the surgical or radiologic attack on a tumor. The text can be read by anyone having even a rudimentary knowledge of French. Rouvière is to be congratulated for planning and writing such an excellent book.

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EFFETS ÉLOIGNÉS DU PNEUMOTHORAX THÉRAPEUTIQUE (Late Effects of Therapeutic Pneumothorax). By DR. L. DE WECK, Physician-in-Chief of the Victoria Sanatorium (Montana). Preface by DR. BURNAND, formerly medical director of the Sanatorium Populaire at Leysin and of the Sanatorium Fonad I, at Helonan, Egypt. A volume of 129 pages, with 16 figures. Published by Masson et Cie, 1932. Price 16 francs.

No one to-day denies the value of the method of Forlanini in the treatment of pulmonary tuberculosis. But among those most partisan to the method there are some who still have doubts as to maintenance of a cure of a destructive lesion after ceasing the insufflations. This is the special point of the author's investigations, undertaken at the suggestion of Burnand. In arriving at his conclusions, the study included a number of questions of capital importance for the understanding of pulmonary physiology and pathology, such as: the mechanism of pulmonary re-expansion; symptomatology of the period of re-expansion of the pneumothorax, internal aspect of the chest after abandoning the treatment; the effect of the pneumothorax on the tuberculous lesion; when to interrupt the pneumothorax and rules to follow in doing so, etc.

Rather than deal with a large statistical group, the author selected 51 cases, including some watched over nineteen years. All the patients were still alive and all had gone through the complete cycle of collapso-therapeutic treatment. Their re-expansion period varied from two to nineteen years, averaging five years. Sixteen unusually well reproduced pulmonary roentgenograms illuminate the text. The book is concise, brimful of valuable information, well classified, and pleasant to read.

JAMES T. CASE, M.D.

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*Wants Standards for Medical Specialists.*—The American College of Surgeons should take up the task of creating standards for practising special branches of medicine, advised J. Bentley Squier, M.D., professor at Columbia University College of Physicians and Surgeons, New York City, in his inaugural address as new president of the College of Surgeons at St. Louis, in October last.

"In the future it will become incumbent for physicians to show a guarantee as to which branch of medicine they are qualified, by adequate training, to practise," Dr. Squier said.

He outlined a plan by which Junior Candidates for Fellowship in the College could acquire the post-graduate training necessary to qualify them as practitioners of surgical specialties. He also advocated for the young surgeons of to-morrow shorter pre-medical training and longer hospital training after finishing medical school. The practical advantages of prolonging the physician's training is seen in a report of the American Medical Association which showed that the largest gross incomes are made by physicians who have spent ten or more years in preparation, and the low gross incomes by those with three or less years of preparation.—*Science Service.*

# ABSTRACTS OF CURRENT LITERATURE

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## APPARATUS

Contribution to the Technic of Seeding of Tumors. Gustav Spiess. Strahlentherapie, April 13, 1932, XLIII, 789-791.

The author describes briefly an instrument for the implantation of radon seeds, particularly applicable for nose, throat, and esophagus. It admits 10 seeds, which can then be inserted without removing the applicator from the endoscope during, for instance, an implantation in a carcinoma of the esophagus.

Ernst A. Pohle, M.D., Ph.D.

The Production of Uniform Radiographs of the Chest. Arnold Engelhard and Hans Sielmann. München. med. Wchnschr., Nov. 20, 1931, LXXVIII, 2002, 2003.

The authors recommend the automatic exposure device of Francke made by C. H. F. Müller, Hamburg. It consists of a photo-electric cell placed behind the special cassette. After a certain amount of energy has struck the cell, the relay connected with it shuts the current off automatically. This device has enabled the authors to produce roentgenograms of chests, which can be well compared with each other, as they show the same amount of density and contrast.

Ernst A. May, M.D.

## THE BLADDER

Possibility of Error in the Roentgen Diagnosis of Bladder Stones. Josef Palugyay. Röntgenpraxis, April, 1932, IV, 317-320.

Cystoscopic examination in most cases shows the presence of bladder stones, except when the stone lies behind an hypertrophied prostate. Stones in a diverticulum might also be missed by the cytoscope. In other cases, cystoscopy is contra-indicated or impossible. In such cases the bladder is filled with air and roentgenograms are made.

Two cases are described in which the roentgen

diagnosis of stones was erroneous. Shadows in the air-filled bladder simulating stones really were caused by a greatly enlarged prostate. A change in the position of the patient might in the future help to avoid such mistakes.

H. W. HEFKE, M.D.

Diverticula of the Bladder. Homero Fleck and Saint Pastous. Rev. Radiol. Clinica, February, 1932, I, 167-173.

The authors report a case of bilateral diverticula of the bladder with two stones which were diagnosed by cystoscopy and cystography. The latter gave definite information about the location, size, and number of the diverticula as well as about their relationship to other organs in the vicinity. Dilatation of the diverticula cured the patient, in whom the risk of resection was excessive.

E. T. LEDDY, M.D.

## BONE (DIAGNOSIS)

The Roentgenologic Displacements in Colles' Fracture: With Special Reference to the Mechanism of the Accompanying Fracture of the Ulnar Styloid: A Report of 100 Consecutive Cases. Louis Carp. Arch. Surg., January, 1932, XXIV, 1-13.

This study was undertaken to show: (1) The usual roentgenologic displacement in Colles' fracture, with an accompanying fracture of the styloid process of the ulna, and the practical therapeutic value of such information; (2) the probable mechanism of fracture of the ulnar styloid.

A study of 100 consecutive cases revealed that the displacements found could be grouped under a few headings in the majority of the cases. These are as follows: (1) Impaction only, 29 per cent; (2) dorsal tilt with impaction, 17 per cent; (3) dorsal tilt with dorsal displacement, 12 per cent; (4) dorsal tilt with dorsal displacement and impaction, 12 per cent; (5) dorsal tilt, 9 per cent. The remainder of the cases was distributed over many different types of displacement.

From the roentgenologic examination, it was found that almost half of the fractures of the ulnar styloid accompanying Colles' fracture occurred at the base. When the alignment between the lower radial fragments and the shaft of the radius was disturbed, there was an accompanying lateral shift and lateral angulation, or both, in the fractured ulnar styloid in most of the cases. With only impaction of the radius accompanied by fracture of the middle of the ulnar styloid, there was lateral shift of the styloid fragments in two-thirds of the cases. When there was fracture of the tip of the ulnar styloid, there was lateral shift in two-fifths of the cases, and when the fracture was through the base of the ulnar styloid, there was no shift of this. Lateral shift of the ulnar styloid is more than twice as frequent as lateral angulation. Medial shift and medial angulation of the ulnar styloid are rare.

A correlation of roentgenologic and anatomic findings suggests that the ulnar styloid in Colles' fractures, in the greatest majority of cases, is fractured at the base by the pull of the intra-articular fibrocartilage of the wrist joint, and at the middle and tip by the pull of the ulnar collateral ligament. Direct violence probably plays a negligible rôle in any of the fractures of the ulnar styloid, although it is possible that this may play a small part.

HOWARD P. DOUB, M.D.

The Use of Auscultatory Percussion for the Examination of Fractures. Robert K. Lippmann. Jour. Bone and Joint Surg., January, 1932, XIV, 118-126.

When roentgen-ray examination is not available, an ordinary stethoscope may be used to determine the presence or absence of fractures of the femur, humerus, or clavicle and may even show the degree of apposition of fragments and the progress of union.

For examination if a stethoscope bell is placed over the antero-superior spine of a normal subject and digital percussion of the patella is done, the examiner hears a sound, the volume and pitch of which are characteristic for conduction through an intact femoral shaft. If the femur is fractured and the ends do not touch, the volume of sound is greatly reduced. If there is fracture, with some degree of apposition, reasonably good conduction occurs, but with diminished volume.

The examination may be conducted through windows in a cast if care is taken that the percussing finger and the stethoscope bell do not touch the cast.

PAUL C. HODGES, M.D.

The Relation of Congenital Deformities of the Hand to Cervical Ribs. Robert V. Funston. Jour. Am. Med. Assn., Feb. 27, 1932, XCVIII, 697-700.

The author reports five cases of club hands, each patient exhibiting cervical ribs when investigated roentgenologically. In five instances in the six club hands present, there was only a small proximal portion of the radius to be seen. In the other case, the radius, although rudimentary, articulated with the carpal bones. He reviews the literature on club hand and congenital absence of bones of the forearm. No reports of coincidental cervical ribs were found. Two additional cases have been added by Shrock and Gaenslen, showing club hand deformities and cervical ribs.

C. G. SUTHERLAND, M.D.